Student Variables and their Influence on the Reliability of Peer Assessment: Assessing Maritime Engineering Graduate Attributes in Problem Based Learning

by
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in
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DECLARATION

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Mark Symes (April 2017)

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DEDICATION

I would like to dedicate this thesis to my wife Vicki and daughter Kate, who without their love, support and encouragement I may have never got to this end, and in memory of my dad, Frank Symes. I wish he could be here to share this moment with me.

ABSTRACT

The work detailed in this thesis investigates the development and assessment of graduate attributes in problem-based learning (PBL). The PBL experience provides students with realistic and challenging tasks, promoting interactive learning while developing graduate attributes.

The study investigated how students perceive peer contribution and interaction, which influences the way they respond in using peer assessment to evaluate contribution, participation and the development of graduate attributes in-group work. The study involved the development of a new approach to the delivery and assessment of graduate attributes in a PBL experience. It brings into question as to whether peer assessment is a reliable method in assessing the attainment of graduate attributes in the problem-based learning environment. This study introduces a more comprehensive and theoretically informed understanding of what affects student variables (Psychological Safety, Value Diversity, Interdependence, and Trust) play in the validity and reliability of peer assessment in a team based active learning experience. The results show there is a direct link to the interpersonal influence of student variables on students performing in this environment. These student variables then have an impact on the reliability of peer assessment.

A Formative PBL assessment model was developed that introduced a team contract, mentor and student reflective feedback process. The latter process enabled the student to provide instructional opportunities that related to their individual result of peer assessment. The outcome encouraged the student to develop purposeful personal and professional understanding of their attainment of graduate attributes. Furthermore, it allowed the students collectively to develop a positive interdependence approach to team development and the project, and their interaction with peer assessment. The development of positive interdependence showed a higher correlation with observed attainment of graduate attributes and a high level of psychological safety in assessing their peers. Students offered insights into the relationship between psychological safety and motivation for learning when taking on peer assessment responsibilities. The developed model is suitable for future work involving the use of peer assessment in PBL and the assessment of graduate attributes.

This study provides new insight into the impact of student variables on the reliability of peer assessment. An important finding in this study is that the Formative PBL-Assessment model 2 presented in this study has clearly identified key elements that influence how students approach and participate in PBL and peer assessment of graduate attributes. The adoption of

the Formative PBL-Assessment model 2 enables students to develop a positive interdependence approach when in a PBL environment. This approach has shown to allow students to develop a deeper approach to interaction in, and understanding of, their learning, attainment of graduate attributes and the outcome of peer assessment.

This study contributes to the understanding of the meaning and consequences of implementing peer assessment into final year design units within Bachelor of Engineering courses and has broader implications in other academic disciplines.

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CHAPTER 1 Thesis Introduction

1.1 Introduction

This dissertation includes two empirical studies and four theoretical contributions on problem-based learning, graduate attributes and peer assessment, which reflect two main tenants of work. Firstly, it presents an investigation into the development of a problem-based learning (PBL) approach to developing and accessing graduate attributes (GA's) in the maritime engineering undergraduate curriculum. The second half provides insight and recommendations to minimise the impact of student interpersonal variables on peer assessment when used to assess GA's.

The research was situated within the Australian Maritime College's (AMC) engineering program. At AMC, PBL has become a favoured educational approach with an aim to improve students' ability to work in teams to solve ill-structured real world and complex problems. The use of peer assessment by students has been widely acknowledged as an important skill in assessing student responses to these complex problems (e.g. Birenbaum &Dochy, 1996; Topping, 2009). More importantly, the use of peer assessment aids students to develop skills or attributes in the areas of, communication, observation, and self-evaluation (Dochy & McDowell, 1997). For peer assessment research to advance and systematically unravel the mechanisms that may impact the validity and reliability of peer assessment and foster student learning, there is a need to consider and integrate information from a wider variety of studies and disciplines.

As a result, the research presented here was not solely an academic exercise, but a route toward a practical, valid and reliable method for accurately assessing the attainment of GA's of maritime engineering students at the AMC involved in PBL that used peer assessment.

1.2 The need for this research

In today's employment environment graduates have to prepare themselves to become self-managed lifelong learners, to ensure ongoing employment success. To facilitate this, Higher Education institutions have employed problem or project based learning as a means for students to develop awareness of learning as a process and emulate real world problem-solving. The primary focus of assessment in higher education is to encourage, direct and reinforce learning. Assessment should also be capable of indicating achievement, maintaining standards and providing certification. A number of studies have shown that embedding graduate attributes into the curriculum, including assessing and evidencing their attainment has been a major challenge for institutions (Radlof, et al., 2008; Oliver, 2011).

Interaction in a student team environment depends on the participants; the behaviour each member exhibits establishes the nature of the relationships within that team. What an individual member does within the team process depends on their individual assessment of, responses to, and expectations about, these interactions. How members behave in this interactional context is influenced, but not limited, to the different ethnic groups, cultures, and interpersonal perceptions which are active in the team (Dochy et al, 1999; Falchikov, 2003).

This socio-culture conception of group work considers the way people act and develop based around their surroundings (Macionis, 1997). This interaction, encompassing role, duties, customs, and beliefs, are what make up the socio-cultural structure of the team. Several recent studies have identified four interpersonal beliefs that are relevant to this study (Edmonson, 1999; Lengard et al., 2002; Van Gennip, 2012), which are described below.

1. Psychological safety: a situation where an individual believes it is safe to take interpersonal risks in a team or group.

2. Value diversity: is the differences in shared understanding of a group's task, goal or undertaking. In peer assessment, value diversity is considered a crucial interpersonal factor in the peer assessment activity.
3. Interdependence: the existence of shared common goals and that each individual's outcomes are affected by the actions of others, be it cooperative or competitive actions. The type of interdependence (cooperative or competitive) might influence how the individual interacts with others.
4. Trust: is the confidence or trust that students have in themselves as an assessor and in their peers as assessors.

Therefore, the effects of team makeup on the validity and reliability of peer assessment used to assess GA's might be better understood if we gained more insight into the interpersonal context and its impact on the reliability of self and peer assessment.

1.3 Research Question

The main objective of this dissertation is to explore the relationship between student interpersonal variables (student variables) and the reliability of peer assessment of graduate attributes in culturally and disciplinarily diverse engineering teams. The study introduces a structure which enables a visualisation of the interpersonal dimensions impacting individual interaction in peer assessment, and the impact of these interpersonal dimensions on attainment of graduate attributes in a team environment.

It was hypothesised that this social interaction has a direct effect on students' responses to peer assessment.

The primary research questions were:

1. **To what extent are the outcomes of peer assessment of graduate attributes related to student variables (psychological safety, interdependence and trust and value diversity)?**
2. **What strategies might mitigate adverse influences of interpersonal variables on the outcomes of peer assessment of maritime engineering graduate attributes in team-based PBL?**

With sub research questions:

1. **Is peer assessment a reliable assessment technique in assessing graduate attributes in engineering PBL?**
2. **Does peer assessment provide valid evidence about students' attainment of graduate attributes?**

1.4 Significance of the study

This research is significant because it develops new knowledge about the impact of student variables on self- and peer-assessment, and particularly with regard to explanatory insights on the assessment of graduate attributes in the problem-based learning environment. Findings from this study will contribute to the fields of peer assessment training, problem-based learning, and the area of Engineering Education research.

First, this study provides a methodological approach to preparing students for undertaking self- and peer-assessment in a problem-based learning environment, which few studies have investigated thus far. This, in turn, allows this study to make recommendations on how to best prepare and support academic staff and students, in a problem-based learning environment, to facilitate and contribute in self- and peer-assessment. Another contribution of this study centres on the refinement and development of processes and scholarship on encouraging students to reflect on the team process and develop skills in receiving and giving constructive feedback to others. The final contribution of this study concerns the investigation of how students practice, and development of the idea that behaviour may influence student's individual perceptions of participating reflectively in self- and peer-assessment activity during their university education.

1.4.1 Graduate attributes (GA)

Graduate attributes express the distinctive skills and competencies intended for a graduating student, in conjunction with their specialist knowledge from the subject area(s) of study (Symes et al., 2011a, Willey & Gardiner, 2004). Similarly, graduate attributes are generally required to be demonstrated to professional organisations by higher education institutes when applying for degree accreditation, and by individual members when applying for professional recognition. For example Engineers Australia (Engineers Australia, 2006) lists the required attributes of graduates from accredited degrees divided into three units of competency:

1. Knowledge and Skill Base
2. Engineering application ability
3. Professional and personal attributes

Engineers Australia goes on to state:

"It is not expected that candidates will have demonstrated every detail of the knowledge, competencies and attributes that follow; but they must demonstrate at least the substance of each element. Assessment will be made in a holistic way."

(Engineers Australia, 2006)

It has been hypothesised that the acquisition of GA's will better prepare engineering graduates for active participation in the local and global world of work, and to act as responsible citizens, aware of their social and environmental responsibilities (Barrie, 2006).

To show how well a graduate can demonstrate competency in a graduate outcome is crucial in a quality assurance approach to undergraduate programmes. Much work has been undertaken in specifying graduate attributes and assessing knowledge or discipline outcomes (Barrie, 2004; Campbell, 2010; Hager, 2006; Symes et al., 2011), but measuring the attainment of graduate outcomes, particularly generic outcomes, is contentious and difficult (Oliver, 2011). The challenge is to find transparent ways of affirming graduate achievements while at the same time ensuring the graduates themselves are assured of their capabilities. The measurement of these generic outcomes can be difficult, time-consuming or indeed perceived as impossible particularly by academic staff who do not feel equipped for these tasks (Green, Hammer & Star 2009; Radloff et al., 2009).

1.4.2 Problem-based learning (PBL)

Problem-based learning (PBL) can be seen as a highly effective model for supporting learning. Research has concluded PBL can be effective in promoting higher order thinking, independent learning, collaborative learning, and knowledge construction (Neo, 2003). PBL is a learner-centred, constructive method with its roots in the health educations system (Engel, 1991). Over time, higher education fields such as engineering education have adopted this method. It has arguably been one of the most important developments since the embedding of professional practice into educational institutions.

In today's employment environment graduates have to prepare themselves to become self-managed lifelong learners, to ensure on going employment success. To facilitate this Higher Education (HE) institutions have PBL or project-based learning (PjBL) as a means for students to develop awareness of learning as a process and emulate real-world problem solving while simultaneously attaining graduate attributes.

In engineering undergraduate programmes, PBL has become common practice undertaken as group work, PBL is reported to encourage deeper learning and promote student autonomy (Topping, 2009). Group work has many benefits for a students' professional development although a major drawback is that it is difficult to determine the individual contributions to group assessment tasks. However, there are many strategies that can be adapted to address such issues. For example, peer assessment of an individual's contribution to the group's work can be used to encourage student participation and overcome the problem of "free riders". Slauijsmans (2002) discussed the additional benefits in students making an active contribution to their own knowledge construction by being actively involved in the assessment process, thereby contributing to their attainment of the learning objectives of PBL.

PBL introduces some unique challenges with respect to assessment. The challenges arise due to the focus of the pedagogy being primarily on learning to learn, rather than the mastery of knowledge. As Major (1999) argues, traditional methods of assessment such as exams may not be very effective when assessing the breadth and nature of learning that PBL is structured and employed to deliver.

1.4.3 Assessment in PBL

Research has shown that student behaviour and student learning are influenced to a large extent by assessment (Black et al., 1998; Bould, 1990; Ramsden, 1992; Scouller, 1998; Thomas & Bain, 1984). Assessment currently appears to be one of the most controversial concerns in PBL (Savin-Baden, 2004).

> *Assessment is at the heart of the student experience,* (Brown and Knight, 1994:1)
>
> *From our students' point of view, assessment always defines the actual curriculum.* (Ramsden, 1992: 187)

The above statements on how assessment influences student behaviour and finally student learning are often quoted in teaching and education in higher education textbooks. They assert that the assessment system has an influence on student behaviour and the learning undertaken in the PBL environment. From the students' point of view, assessment always defines the actual curriculum. (Ramsden, 1992:187).

In practice, informal assessment with no associated mark (formative assessment) helps the learners move toward a viable solution to their PBL challenge. Formal assessment associated with marks can take place at specific points within PBL. A range of traditional and authentic assessment methods can be used to measure the more technical aspects of the PBL response including, content knowledge, the workflow, the solution, documentation and implementation.

This type of practical evaluation is much closer to how the work carried outside of the education environment is evaluated.

1.4.4 Peer assessment

Peer-assessment is a common form of shared learning in which students provide feedback on each other's work. It improves the quality of learning and empowers students; McDowell and Mowl (1996). However, little research has been undertaken to investigate the assessment of a student's obtainment of "soft" or industry required skills in PBL. Skills such as communication, behaving professionally, organisational capacity and effectiveness at teamwork have often been assumed to have been obtained by merely participating in PBL activities (Sluijsmans et al., 2001). If peer assessment is to be used it must be fit for purpose, in that if implemented it must be valid and reliable. It is now well established that peer assessment is a common assessment tool used in PBL. However, the influence of student variables on the validity and reliability of peer assessment in assessing the attainment of GA's has remained unclear. This thesis addresses that gap in the literature, scholarship and implementation of peer assessment for GA learning in engineering education.

1.5 Thesis Structure

This dissertation includes two empirical studies and four theoretical contributions on problem-based learning, graduate attributes and peer assessment, a general introduction, a discussion of the results and a discussion on the educational implications of this research.

The six main chapters (Chapters 2 – 7) take the format of manuscripts, each with their own abstract, introduction, methodology, results and conclusions. This format comprises academic papers forming discreet thesis chapters, with framing text introducing the research and linking each of the chapters and papers, into a unified body of original work.

Chapters 2,3,4,6 and 7 have been submitted to national or international engineering education conferences or journal. The academic value of the publications is important and, as such, only double-blind peer reviewed conferences and journals papers that had been accepted for publication were selected for inclusion as chapters in this thesis.

The six main chapters of this thesis can be read on their own as each deals with a different conceptual area or empirical question within the area of peer assessment and the attainment of graduate attributes. As for a conventional thesis format, the outcome is a sustained and cohesive theme which is maintained throughout the document. However, some overlap in the introductory sections within chapters could not be avoided, as each manuscript is in its own right a stand-alone contribution. The common theme is the attainment and assessment of graduate attributes in the PBL environment.

Figure 1-1 provides a representation of the topics of the six main chapters and their relationships as a cohesive body of work. The relationships between chapters are further elaborated below.

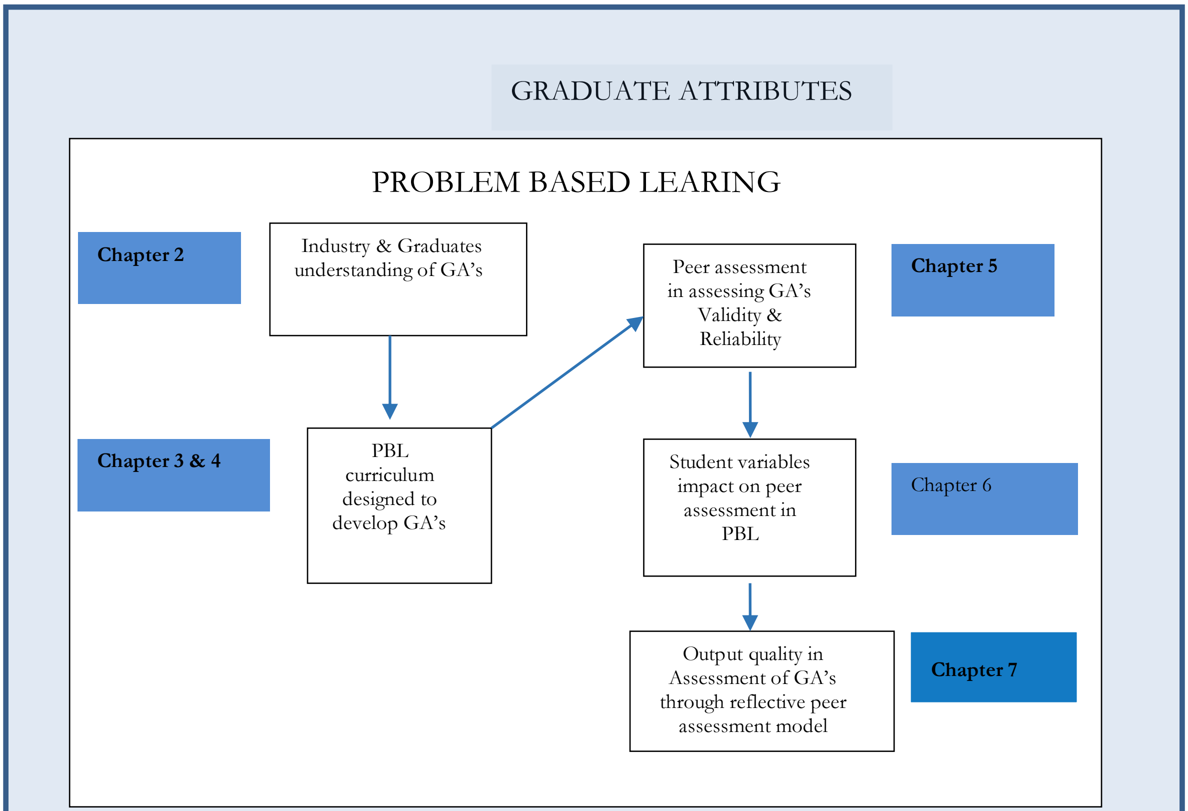

Figure 1-1 Overview of the main chapters of this dissertation

Chapter 2, 3, and 4 set the framework for the study of assessing and attainment of GA's. These chapters investigate the importance, development and implementation of a PBL approach adopted to impart GA's in an undergraduate Maritime Engineering programme.

Chapter 5 informs through a review of the literature, the link between attainment of GA's in PBL and the valid and reliable use of peer assessment in assessing GA's in a PBL environment.

Chapter 6 address the impact of student variables on peer assessment as a valid and reliable method in assessing GA's in PBL.

Chapter 7 introduces the development, evaluation and implementation of the PBL-Formative assessment model to improve the reliability of peer assessment.

Chapter 2 (Paper 1 - Graduate attributes: industry and graduate perceptions)

This chapter examines the relevant industry stakeholders and graduates hold in the graduate attributes developed at the Australian Maritime College.

The findings show that industry desires a high level of proficiency across the full range of graduate attributes, and in particular seeks strong competency in the so called 'soft skills' such as communication skills and working with information. The graduates they have employed were assessed as operating at an overall standard slightly below that desired, particularly in areas such as: 'Negotiate the business environment' and 'Behave as a professional'. This data has been used as valuable information in the continuous cycle of improvement in AMC engineering courses, aiding the redesign of the course, units and assessment to ensure that the appropriate attainment of graduate attributes is achieved.

Chapter 3 (Paper 2 - A sequential Project Based Learning programme designed to meet the graduate attributes of engineering students.)

This chapter focuses on the development of a project based approach undertaken at the Australian Maritime College in progressively developing new techniques to deliver and assess graduate attributes via holistic tasks, thus ensuring a broader coverage of the attribute spectrum within an environment of limited resources and time. The paper shows that by integrating PBL aligned with industry practice and assessed against graduate attributes, it is possible to address the needs of both industry and society.

Chapter 4 (Paper 3 - An Integrated Delivery and Assessment Process to Address the Graduate Attribute Spectrum.)

Chapter 4 focuses on the mapping tool developed and used to analyse and track the attainment of graduate attributes. The mapping tool provides a framework to capture and rate the level of attainment of the attributes. Concurrently with this development, a practical and simple method of tracking and quantifying the achievement of the attributes by the students is described. This work yielded useful data to improve processes within the programme, and, hence, the quality of graduate attainment.

Chapter 5 (Paper 4 – Student peer assessment in engineering PBL education: a systematic review.)

This paper reports a systematic literature review examining empirical studies on the use of peer assessment in PBL. An important characteristic of group work is the ability of team members to evaluate each other's performance, but it must also include the evaluation of learning outcomes and implied knowledge and skills developed.

This study aims to give an overview of the use of peer assessment in the PBL environment in the assessment of graduate attributes, and attempts to answer the questions;

1. Is peer assessment a reliable assessment technique in assessing graduate attributes in Engineering PBL?
2. Does peer assessment provide valid evidence about students attainment of graduate attributes?

Peer assessment has been demonstrated to be an effective educational intervention in PBL. But questions could be raised as to the validity and reliability of using the peer assessment instrument when assessing GA's. Such an instrument can only be justified by its sufficient reliability and validity, as well as the discriminative purposes of the assessment. It has been shown in this research that student variables may have an impact of the outcome of peer assessment.

Chapter 6 (Paper 5 - Interpersonal variables and their impact on the perceived validity of peer assessment in Engineering PBL.)

Chapter 6 is empirical in nature, the focus lies on 'peer assessment as a tool for assessing the attainment of graduate attributes' and the impact of student variables on the 'validity' and 'reliability' of peer assessment. Preliminary findings from this study and evidence from other studies support the view reported in Chapter 5 from literature review, that student variables have the potential to affect peer assessment and influence the learning outcomes.

Chapter 7 (Paper 6 – Reflective interaction of peer assessment in undergraduate Engineering PBL.)

Chapter 7 focuses on peer assessment itself in PBL but goes beyond its impact on the perceived influence student variables have on the process, by analysing all the goals peer assessment can serve in a PBL setting. It sets out to provide insight and guidelines that have been shown in this body of work, to minimise the impact student variables have on assessing GA's and the reliability of self- and peer-assessment.

Chapter 8 Final Reflections and Conclusion

This chapter closes this dissertation with some final reflections. It contains a summary and discussion of the results, in which the individual studies examined and results summarised. The process of integrating findings from across the preceding 6 chapters demonstrates with great clarity, the original contribution of this dissertation to the educational theory, its wider practical significance for the advancement of engineering education pedagogy and offers suggestions for further research.

CHAPTER 2 Graduate Attributes in Maritime Engineering

This research originally published as;

"GRADUATE ATTRIBUTES: INDUSTRY AND GRADUATE PERCEPTIONS"

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Proceedings of the RINA International Conference on the Education and Professional Development of Engineers in the Maritime Industry.

Singapore, February 2013

This chapter has been removed for copyright or proprietary reasons.

Symes, MF and Thomas, GA and Ranmuthugala, SD, Graduate Attributes: Industry and Graduate Perceptions, 2nd International Conference on the Education and Professional Development of Engineers in the Maritime Industry, 26-27 February 2013, Bukit Timah, Singapore, pp. 80-86. ISBN 9781909024120 (2013)

CHAPTER 3 Embedding Graduate Attributes Into Problem Based Learning

This research was originally published as;

"SEQUENTIAL PROJECT BASED LEARNING PROGRAMME DESIGNED TO MEET THE GRADUATE ATTRIBUTES OF ENGINEERING STUDENTS"

Mark Symes[1], Dev Ranmuthugala[1], Anna Carew[2]

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Proceedings of the 22nd Annual Conference for the Australasian Association for Engineering Education, Fremantle, Western Australia,

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3.1 Abstract

Current Australian engineering curriculum focuses strongly on engineering science and is typically technically based and content driven. Often insufficient emphasis is placed on relating content to current industry practice and generic skills. Courses taught with many practical examples drawn from real life or incorporate industry practice better prepare students for situations that they have not previously experienced. Courses that are heavily theory based are often taught at speed, without providing students with time to assimilate the material. Many institutions utilise "assignment projects", "problem-based learning" (PBL), or "project based learning" (PoBL), but are they adequately structured and assessed? There is a need for better alignment of assessment with the overall course outcomes, therefore, bringing about the desired behavioural change within undergraduate students, enabling them to attain the required graduate attributes.

The Australian Maritime College is progressively developing new techniques to deliver and assess these attributes through holistic tasks, thus ensuring a broader coverage of the Attribute Spectrum within an environment of limited resources and time. This provides students with realistic and challenging tasks, a far cry from the traditional mundane 'engineering laboratories', thus promoting interactive and practical problem based learning, making the study of engineering enjoyable! The paper shows that by integrating PoBL aligned with industry practice and assessed against graduate attributes, it is possible to addresses the needs of both industry and society.

3.2 Introduction

The values of graduate attributes are recognised as being important in improving the lifelong learning skills of graduates. These attributes can broadly be divided into two categories, one focusing on the technical knowledge and skills required within the relevant industries and the other emphasising the generic attributes that are defined as "skills, knowledge, and abilities of graduates beyond disciplinary content knowledge, which are applicable in a range of contexts" (Barrie, 2006, p. 217). It can be argued that most academic institutions wrestle with the issues of quantifying the level of emphasis required in each category as well as identifying how to meaningfully deliver and assess the generic attributes. This is further exacerbated due to the continuous pressure to increase the technical content to meet technological advances, multi-skilling, and changing work practices. As Barrie & Prosser (2004) state graduate attributes must seek to describe the core outcomes of a higher education programme, and thus the purpose and nature of the programme, not just the technical outcomes.

In the past, the Australian Maritime College (AMC) engineering programmes were developed with separate technical learning outcomes supplemented by generic attributes. Unfortunately, the emphasis during delivery and assessment was on the former, with the generic attributes addressed, if at all, through secondary activities which were usually given a lower level of importance. As stated by Radloff et.al. (2008) embedding graduate attributes into the curriculum 'has thrown up major challenges for universities'. Engineers Australia has mandated the requirement for the teaching, learning, and assessment of generic attributes in Australian undergraduate engineering programmes by creating a number of competency standards and linked attributes that graduates are required to meet during their period of study (Engineers Australia, 2006). However, the actual strategies in delivering, assessing, and tracking these are left to the individual academic institutions, although these methods are 'audited' during the cyclic accreditation process.

In the past, the trend within academic institutions was to develop engineering programmes focused on delivering, assessing, and tracking the technical attributes, with the generic attributes addressed through secondary processes usually 'added on' to the programme at convenient locations (Barrie, 2006; Hguyen, 1998). However, there has been a significant awakening within the sector, with the educational institutions, industry, and the accreditation bodies all placing a far greater importance on the generic attributes, resulting in a push to develop innovative and efficient methods to impart these skills to graduates (Carew & Therese, 2007). This has required educators to clearly identify the required attributes, develop methods of delivering and assessing both the technical and generic attributes through integrated processes, and track the attainment of all attributes. This requires a rethink of the programme structure rather than superficial changes to existing programmes, as well as a commitment to move away from traditional delivery and assessment processes.

The AMC has embarked upon an integrated approach that describes the objectives, outcomes, and attributes as a continuum to ensure that the developed learning strategies adequately address the needs of both industry and society. These are delivered and assessed through a series of problem based holistic practical projects carried out early in the programme.

3.3 The Attribute Spectrum and Mapping

AMC has embarked on a process of redefining the graduate attributes by developing an integrated set of course objectives, outcomes, and attributes defined as the Attribute Spectrum, that incorporates both the technical and generic attributes. It provides the foundation to develop comprehensive learning and assessment strategies and tools. The complete Attribute Spectrum consisting of 63 attributes within 10-course outcomes is described in Symes et al. (2011), which differs from the traditional approach of having separate technical and generic attributes as in the example given by Carew et al. (2008). In addition, the spectrum delves deeper into the required competencies, forcing those involved in the delivery and assessment to develop appropriate tools and strategies.

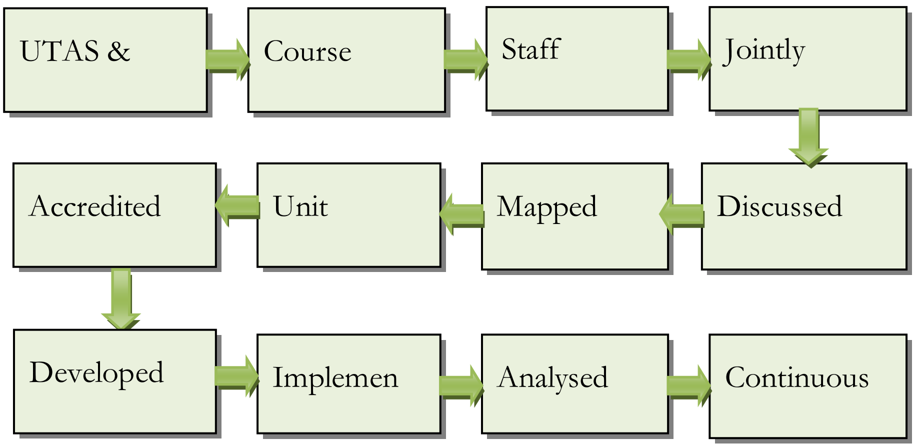

Figure 3-1 Flow Diagram

The development and implementation process of the Attribute Spectrum, its delivery, assessment strategies, and tracking system is shown in Figure 3-1. Unlike previous processes, the use of the Attribute Spectrum links the technical and generic outcomes across all AMC engineering programmes. To ensure that attributes are not treated discreetly, assessments should be structured and undertaken as holistic activities. No individual unit will address every attribute however, it is expected that the students will attain and develop the attributes incrementally across the degree programmes. Carew et al. (2008) reports that the early approach of using the 'tick-a-box matrix' method to report generic attributes is deemed insufficient and requires a comprehensive explanation of how the programmes help students systematically develop these attributes, and how the assessment procedures ensure they have done so.

The Attribute Spectrum developed for the AMC engineering degree programmes are tabulated and monitored through an online database, of which a screen dump is shown in Figure 3-2.

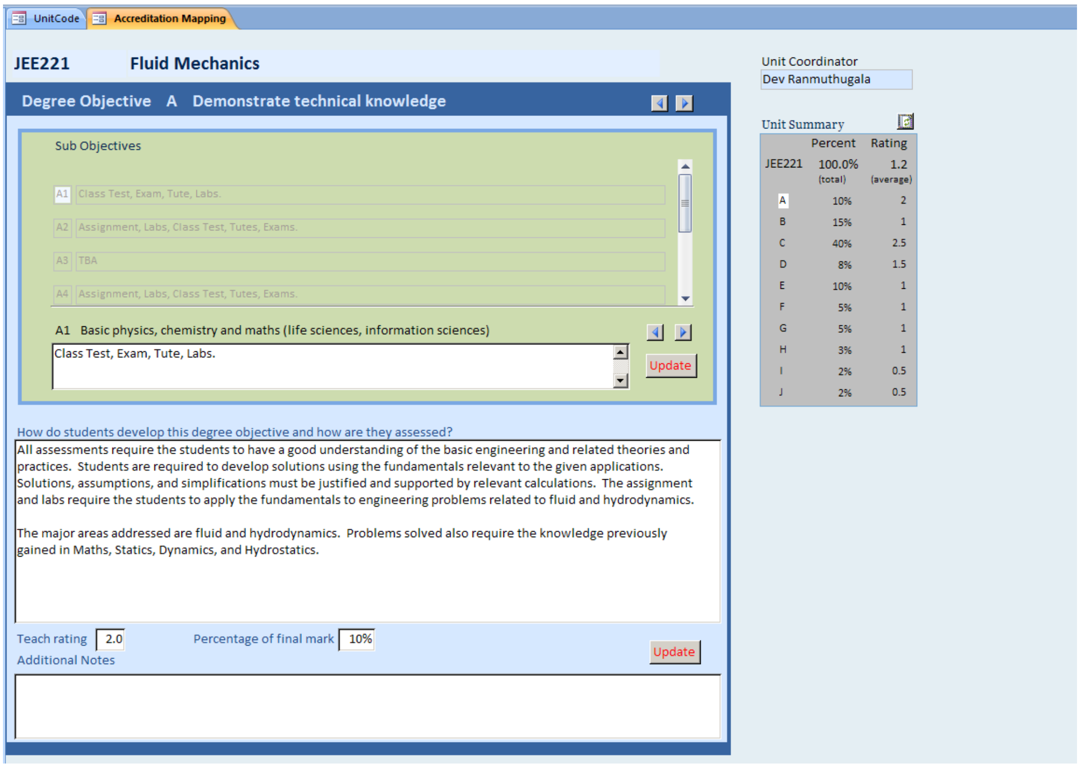

Figure 3-2 Attribute Mapping Database

The intention is to develop a system that tracks the attributes attained by each student, however; currently, the system only tracks annual cohorts of students. In its current form, it allows the course coordinators to 'fine-tune' the programmes in both delivery and assessment strategies. The database provides a number of output graphs to assist in the analysis of the delivery and assessment processes as shown in Figure 3-3. It provides a basis for discussion on the extent of coverage, timing of coverage, and intensity of assessment within the programme in line with the objectives. A more detailed description of these is given in Symes et al. (2011).

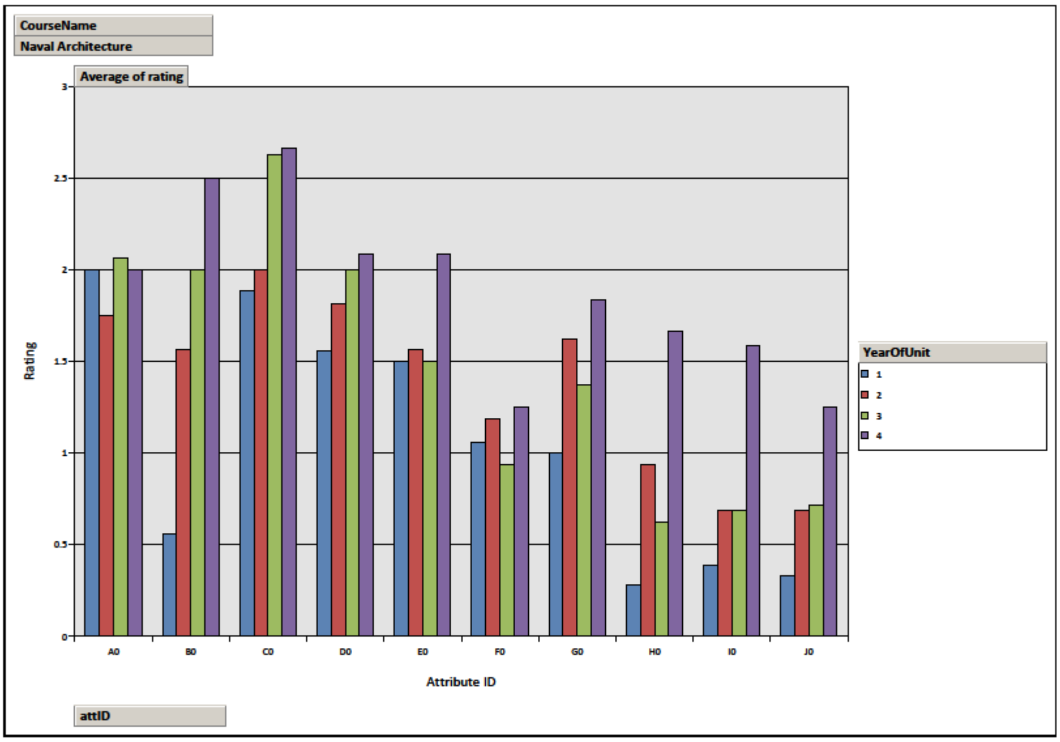

Figure 3-3 Average Percentage of Final Mark against the Course Outcomes

3.4 Attainment of the Attribute Spectrum

In industry, generic attributes tend to cluster (Hagar & Holland, 2006), while academically it is easier to assess them individually. In practice, however, they tend to overlap and interlace. Professional engineering practice is holistic and requires the use of attributes in changing combinations. For example, an engineer developing a solution for a client may simultaneously communicate with the client to meet their requirements, whilst reasoning analytically within budgetary constraints.

During the development of the mapping database, it was evident that the delivery and assessment processes had to cover a wider spectrum, which could not be achieved successfully under the existing system due to time constraints and student fatigue. As the existing delivery and assessment processes were targeting technical content, the inclusion of generic attributes would require additional processes. This required a rethink on how to deliver and assess both the technical and generic attributes through integrated holistic processes. The approach taken by AMC was to develop a series of problem based holistic practical projects across the programme that addressed a number of attributes. The advantage of the Attribute Spectrum was immediately evident as it allowed the development of appropriate projects, and equally important, the direction these projects were allowed to evolve (Symes et al., 2011). The links within the Attribute Spectrum and the feedback from the tracking database provided a foundation to create projects that covered a range of attributes while maintaining focus on the relevant industries.

The Attribute Spectrum also provided the basis for the assessment criteria within the Criterion Based Assessment (CRA) schedule, an essential tool to provide guidance for the students during the projects and assist in the grading of the process and the product. While the use of the Attribute Spectrum made the process a lot simpler, it also enabled the programme coordinators to track the delivery and assessment of the attributes early in the learning process and provide input to the tracking database.

The AMC's engineering programmes consist of four problem based holistic practical projects, carried out in the first four semesters of study and increasing in complexity over that period. These group projects gradually introduce the students to the relevant content while providing a vehicle to attain the required attributes. The last of these projects are carried out in the unit Fluid Mechanics, where the students' design and build a working model submarine. This is an example of a project providing realistic and challenging tasks, promoting interactive and holistic problem based learning that links the relevant theory to practical work. Students engaged in active learning are able to directly create the link between theoretical knowledge and the practical problem (Chartier & Gibson, 2007), as well as allowing the facilitation of learning in students who might otherwise be disadvantaged. During subsequent years, the students build on the attributes attained to develop their knowledge and skills and perform tasks that are more complex.

The project spans a whole semester and is undertaken in groups of six to eight students allocated from all degree programmes. They are required to design, construct, and test a model submarine (see Figure 3-4) to meet operational specifications. The group submits two reports, which include: project plans, resource allocation, literature review, relevant theory, design calculations, drawings, testing schedule, results, discussion, conclusion, and recommendations. The assessment includes testing the vehicle against the specifications and a peer review process. The discussion provided below under each course outcome explains how the content is delivered and the outcomes assessed through a predefined CRA based on the relevant technical and generic attributes identified through the Attribute Spectrum.

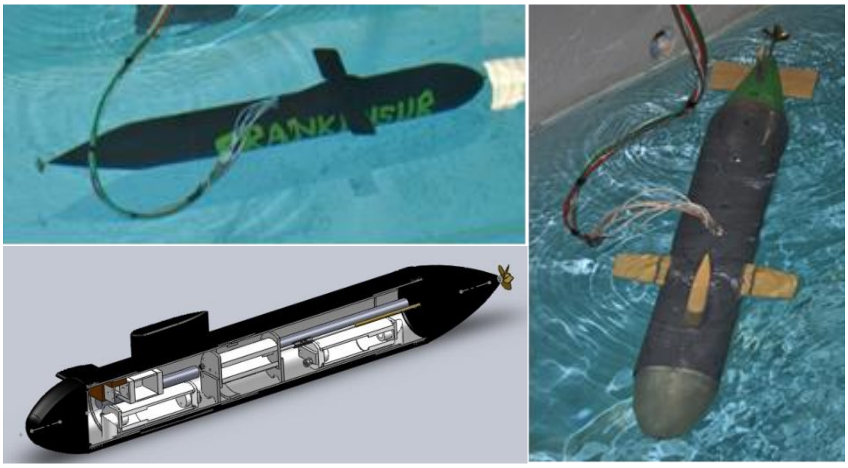

Figure 3-4 Model Submarine Project

Outcome A - Demonstrate Technical Knowledge

The assessment tools, wherever possible, are linked to actual problems, with students required to apply industry standards and practices, and knowledge from other units to their solutions. They are encouraged to look for options and solutions from industry. Given that the submarine itself is designed from minimal information (nonprescriptive), the solutions generated by the students are unique, effectively creating a barrier against plagiarism, while promoting design and innovation.

Outcome B - Design for the Maritime Environment

Design is embedded within the project, with the students given a design brief to produce a workable submarine model to given specifications using industry standards and practices, and importantly common sense, an attribute frequently overlooked. The design must be supported with adequate and accurate calculations, clearly stating the assumptions made during the process.

Outcome C - Solve Maritime Engineering Problems

Students are given engineering problems, which requires them to identify the requirements, constraints, and the 'tools' required to solve the problems, an important attribute as most students find it difficult to decide on a solution approach. They are required to identify various operational conditions peculiar to submarines, such as stability, internal and external forces, and structural integrity, including making drawings of the vessel and related systems. They then carry out calculations, including stability, pressure, drag, lift, thrust and power to identify limitations, failure, and vessel dimensions, relating them back to their drawings. The project makes students identify logical patterns and pathways to solve the problems rather than taking a 'scatter gun' approach.

Outcome D - Manage, Create, Use and Disseminate Information

The design brief requires the students to search for information through a number of avenues, including references, publications, the internet, and discussions with external sources. The project is heavily dependent on students collectively and individually acquiring information from a range of sources, and their ability to sort the data into different categories depending on their speciality, relevance, currency, and quality. They are required to maintain evidence in the form of design files, work plans, and controlled documents that are all assessed.

Outcome E - Communicate Effectively

A greater focus is placed on informal communication, group dynamics, and internal and external stakeholders. The project requires the teams to provide a complete preliminary design, including supporting documents in line with industry practice. The students are required to source information through a number of avenues, which include communicating with internal and external personnel, providing continuous updates on their progress, and presenting a final report. The large and diverse groups require well thought out communication strategies.

Outcome F - Work in Teams

Students must manage and distribute the workload between the team members, and provide group reports on their findings and results. The groups are allocated by the lecturers rather than allowing like-minded students to form groups, requiring them to actively work on building good team dynamics with students from different backgrounds and resolving any conflict. Time and resource allocation is carried out by the team and its leadership, which requires acceptance by all to ensure success. The assessment includes peer assessment that relates group dynamics and individual contributions.

Outcome G - Manage Self and Others

The project is open-ended and deliberately lacks sufficient information for a straightforward solution. The students have to investigate the design requirements to fill in the gaps, before moving on to the solution. The latter requires an iterative approach, generating additional input and further investigations. Given the complexity of the task which is carried out within a normal semester, students are required to manage their time and workload. To ensure success, the team has to assist and mentor each other as well as managing the collective efforts of the group.

Outcome H - Negotiate the Business Environment

To successfully meet the design brief, students must investigate and incorporate commercial and industry requirements. To enable students to achieve the outcomes, a number of lectures, including those by technical and non-technical professionals from related industries and organisations are provided. They introduce new concepts, expand on current knowledge, and provide forums for discussions on relevant areas. Students also research and obtain information from various internal and external sources on commercial operating principles and procedures.

Outcome I - Behave as a Professional

Given that the project requires construction and testing in a freshwater pool of sufficient depth to ascertain the submarine's diving ability; identifying and adhering to all relevant safety and environmental issues are essential and assessed. Given the nature of the issues, staff members continuously provide advice and assistance as required. Students are also assessed on their professionalism during the project, especially when working within their team and dealing with internal and external personnel.

Outcome J - Consider Wider Context of Engineering Knowledge and Work

The project is assessed for technical content, innovation, feasibility, suitability, environmental impact, maintenance, *etc*. Thus, students are introduced to regulations, equipment, and procedures within the maritime and related industries to protect the environment, *e.g.* the prevention of marine pollution from vessels at sea. This includes incorporating them into the design and construction work. Students are also exposed to embedded lectures by qualified industry professionals during the project.

3.5 Conclusion

Engineering industries are continuously evolving to meet changing world demands and practices. Therefore, higher education engineering programmes themselves have to change to remain viable and relevant to the industry, community, and the students. It is important that the programmes meet both the technical and generic skills required by the industry and the community. The trend in the past was to 'append' the generic attributes to the technical content within course curriculum in the hope that they would be covered during the delivery and assessment processes that concentrate on the technical aspects. The tracking mechanisms for graduate attributes are in their infancy, a number of institutions are developing methods to track individual and group attainment of the attributes (Nouwens, 2007).

AMC has developed an integrated approach that describes the objectives, outcomes, and attributes as a continuum defined as the Attribute Spectrum. As this links the technical and generic attributes, it allows the development of integrated delivery and assessment processes. A major feature of the process is the introduction of four problem based holistic practical projects carried out in groups during the first four semesters of study, with the final project described in this paper. The Attribute Spectrum enabled the projects to cover a range of technical and generic attributes as well as the development of the required CRAs. They provide a holistic approach to the assessment and attainment of the required attributes. By creating a series of problem based holistic practical projects early in the programme, students attain required competencies to deal with more advanced tasks in later years of the programme. Tracking of the attributes is carried out via an online database that currently provides information on cohorts of students, with plans underway to upgrade it to track individual students. Although these projects cannot fully replace other delivery and assessment techniques, it should form a major component within any programme aiming to deliver industry ready engineers.

CHAPTER 4 Graduate Attributes in Maritime Engineering PBL

Development and Assessment of Graduate attributes

This research was originally published as;

"AN INTEGRATED DELIVERY AND ASSESSMENT PROCESS TO ADDRESS THE GRADUATE ATTRIBUTE SPECTRUM"

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4.1 Abstract

In the past, engineering programmes were developed with separate technical learning outcomes supplemented by generic attributes. The latter was in most cases a standalone set of attributes developed by academic institutions or professional societies overseeing engineering accreditation processes. Although the technical learning outcomes were well assessed and tracked, the generic attributes were at best partially addressed by artificially incorporating them into the curriculum as a way of "ticking-the-boxes". The current trend is to define competencies that map attributes required across the industry and develop programmes that have embedded tools to deliver and assess these attributes. The Australian Maritime College is progressively developing new techniques to deliver and assess these attributes through holistic tasks, thus, ensuring a broader coverage of the attribute spectrum within an environment of limited resources and time. This provides students with realistic and challenging tasks, a far cry from the traditional mundane engineering laboratories, thus, promoting interactive and practical problem-based learning, making the study of engineering enjoyable! Concurrently with this development is a practical and simple method of tracking and quantifying the achievement of the attributes by the students, yielding useful data to improve processes within the programme, and, hence, the quality of the graduates.

4.2 Introduction

Graduates from engineering degree programmes must have a good understanding and appreciation of the profession and industry they are about to enter through sufficient professional development within their programme of study. Most within the industry and academia recognize the need for adequate and relevant technical contents supplemented by appropriate graduate attributes, as supported by Barrie and Prosser (2004) who stated that, Graduate attributes seek to describe the core outcomes of a higher education. In doing so, they specify an aspect of the institution's contribution to society and carry with them implicit and sometimes explicit assumptions as to the purpose and nature of higher education. (p. 244)

Although the value of graduate attributes were recognized as important in improving the lifelong learning skills of the graduates, most academic institutions wrestled with the issues of quantifying the level of emphasis required as well as identifying how to meaningfully deliver and assess these attributes. This was further exacerbated due to the continuous pressure to increase the technical content to meet technological advances, multi-skilling and changing work practices.

In the past, engineering programmes were developed with separate technical learning outcomes supplemented by generic attributes. Unfortunately, the emphasis during delivery and assessment was on the former, with the generic attributes addressed, if at all, through secondary activities that were usually given a lower level of importance. Most higher education institutions have embedded generic skills and attributes into their curricula in an attempt to force their delivery, although the results have been mixed.

The teaching, learning and assessment of generic attributes in Australian undergraduate engineering programmes are mandated by the professional accreditation body, EA (Engineers Australia) (The Institution of Engineers, Australia). EA has created a number of competency standards and linked attributes that graduates are required to meet during their period of study (EA, 2006). However, the actual strategies in delivering, assessing and tracking these are left to the individual academic institutions, although these methods are audited during the cyclic accreditation process. The old "tick-the-box" approach of reporting generic attributes is no longer deemed sufficient as it provides little quantitative and qualitative evidence, as well as failing to differentiate between what was taught and learnt.

The current trend within academic institutions providing professional engineering education is to define competencies that map attributes required across the industry and develop programmes that have embedded tools to define and assess these attributes throughout the learning process. Defining competencies, that can accurately map attributes with the aim of addressing generic industry requirements as well as maintaining technical competence, has and will continue to prove challenging. As a result, new and innovative methods of imparting generic attributes are rare and often short-lived. The department of maritime engineering at the AMC (Australian Maritime College) (an Institute of the UTAS (University of Tasmania)) has embarked upon an integrated approach that describes the objectives, outcomes and attributes as a continuum to ensure that the subsequently developed learning strategies adequately address the needs of both industry and society. The delivery and assessment is carried out through problem-based learning projects embedded within the programmes, while tracking is based on a database, albeit yet under development.

4.3 The Attribute Spectrum

AMC embarked on a process of redefining the graduate attributes, using a “clean slate” approach to develop a single structure, that is a common set of course objectives, outcomes and attributes for all (three) programmes taught at AMC, which incorporated and integrated the course technical and generic outcomes and attributes. These were derived through lengthy consultation and negotiation processes with internal and external stakeholders, to provide an outcome that represented an all-encompassing structure as well as a clear and comprehensive statement of the graduate qualities, knowledge and experience, specific to graduates from AMC’s maritime engineering degrees.

The first step was to develop the integrated course objectives, outcomes and attributes. This had to meet the technical contents as well as the generic attributes while adhering to the requirements stipulated by the relevant industry sectors, accreditation bodies and UTAS, while also catering to students of varying backgrounds.

AMC embarked upon an integrated approach that described the objectives, outcomes and attributes as a continuum, defined as the attribute spectrum, to ensure that the subsequently developed learning strategies adequately met all required attributes.

This also allowed academic staff to develop delivery and assessment tools that inherently met the competencies expected by the graduates. The complete attribute spectrum consisting of 63 attributes under 10 course outcomes is given in AMC (2010), with the latter reproduced as follows:

(1) Demonstrating technical knowledge;

(2) Designing for the maritime environment;

(3) Solving maritime engineering problems;

(4) Managing, creating, using and disseminating information;

(5) Communicating effectively;

(6) Working in teams;

(7) Managing self and others;

(8) Negotiating the business environment;

(9) Behaving as a professional;

(10) Considering the wider context of engineering knowledge and work.

The self-explanatory flow diagram shown in Figure 1 chapter 2 represents the processes undertaken during the consultation and development stages. The objectives, outcomes and attributes were developed by the course coordinators, with due consideration to the EA competency standards for professional engineers (EA, 2006) and the UTAS graduate attributes.

They were refined through a series of consultations with stakeholders, such as industry, staff and students. The approved structure provided the foundation to develop and/or modify the individual unit objectives and outcomes, which in turn led to the development of appropriate delivery and assessment strategies.

The formal step in this process is the cyclic accreditation, which began with the UTAS internal accreditation. This was followed by the EA external professional accreditation. The latter included the RINA (Royal Institution of Naval Architecture) and the IMarEST (Institute of Marine Engineers, Science and Technology) in order to secure their recognition.

The difference between this and the conventional method of developing such strategies was the use of the attribute spectrum, which reflected the technical and generic outcomes across all maritime engineering programmes at AMC.

A major revelation evident early in the process was that the delivery and assessment process had to cover a wider spectrum, which could not be achieved successfully under the existing system due to time constraints and student fatigue. As the existing delivery and assessment processes were targeting technical content, the inclusion of generic attributes would require additional processes. This required a rethink on how to deliver and assess both the technical and generic attributes through integrated holistic processes.

The approach taken by AMC was to develop a series of problem-based holistic practical projects across the programme that addressed a significant number of attributes. The advantage of the attribute spectrum was immediately evident as it allowed the development of appropriate projects, and equally important, the direction these projects were allowed to evolve. An example of a project employed to meet the attribute spectrum is given later in this paper.

The attribute spectrum also provided the basis for the assessment criteria required to develop a CRA (criterion based assessment) schedule, an essential tool to provide guidance for the students during the project and assist in the grading of the process and the product. The use of the attribute spectrum made the process a lot simpler, a welcome development to any academic who has had to develop a comprehensive CRA.

4.4 Graduate Attribute Mapping

Research has shown that in industry, generic attributes tend to cluster (Hagar & Holland, 2006), while academically it may be useful to assess attributes individually. In practice, however, they tend to overlap and interlace. Professional engineering practice is holistic and requires the use of attributes in changing combinations. For example, an engineer developing a solution for a client may simultaneously communicate with the client to meet their requirements, while reasoning analytically within budgetary constraints.

To ensure that attributes are not treated discreetly, assessments should be structured in such a way to ensure they are undertaken as a holistic activity. No individual unit will address every attribute, however, it is expected that the attributes be developed incrementally across the degree programmes.

Carew, Lewis and Letchford (2008) reported that the early approach of using the "tick-a-box matrix" method to report generic attributes is deemed insufficient and EA accreditation panels expect academic institutions to provide "comprehensive explanations of how the programs help students systematically develop these (generic) attributes and how the assessment procedures ensure they have done so" (p. 2).

The attribute spectrum developed for the AMC engineering degree programmes (AMC, 2010) are tabulated and monitored through an online database, of which a screen dump is shown in Figure 4-1. This approach evolved from the previous work carried out by Carew (Australian Learning & Teaching Council, 2009) to audit and map teaching and learning of graduate attributes in engineering. The intention is to develop a system that tracks the attributes attained by each student, however, the system is in its infancy and only tracks annual cohort of students. Although this system in its current form has limitations, it allows the course coordinators to fine tune the programmes in both delivery and assessment strategies, in other words provides quality feedback essential to meet the required outcomes.

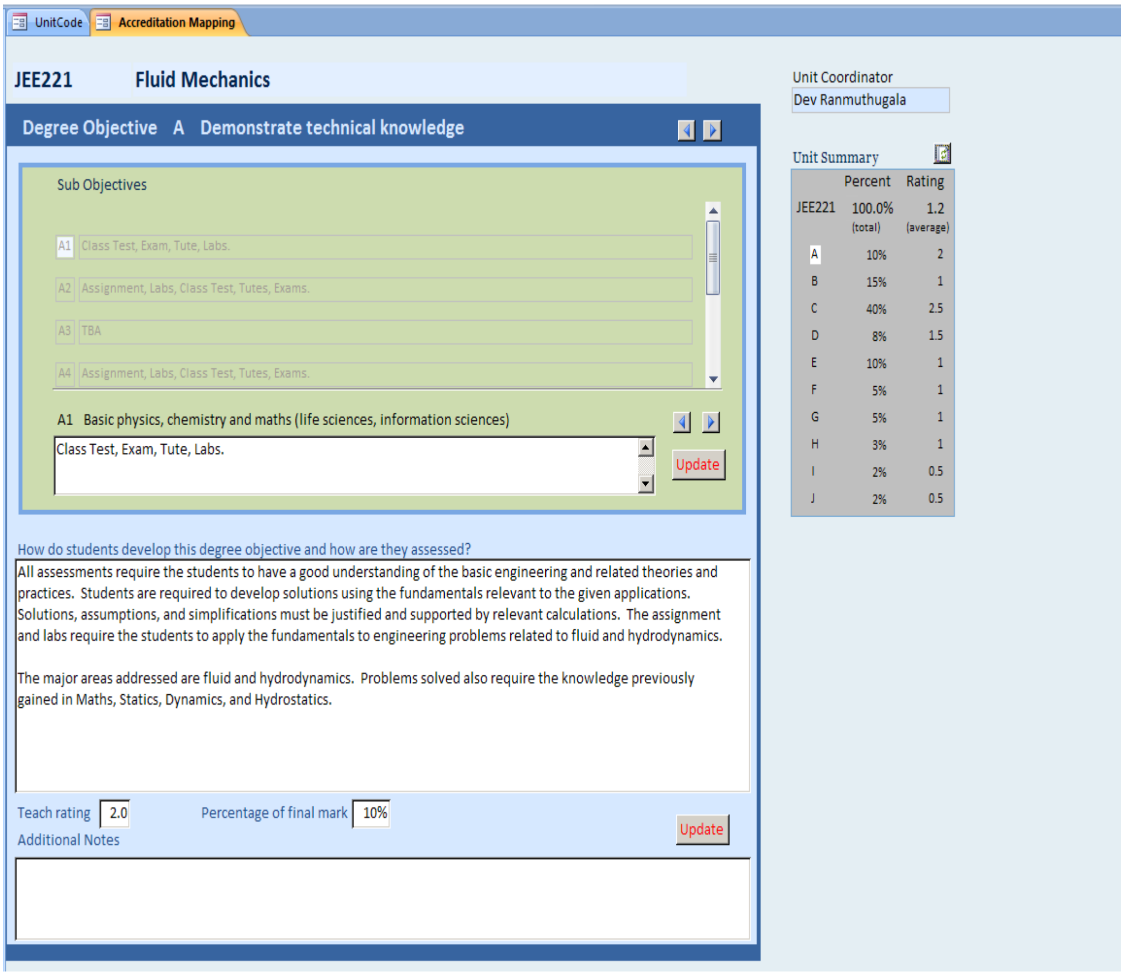

Figure 4-1 Mapping database.

The database provides a number of output graphs to assist in the analysis of the delivery and assessment processes. The graphs shown in Figures 4-2 and 4-3 are examples of such outputs for the Bachelor of Engineering (Naval Architecture) programme at AMC. It provides a basis for discussion on the extent of coverage, timing of coverage and intensity of assessment within the programme in line with the objectives.

Figure 3 shows the average teach rating an indicator of teaching "input"; that is the extent of effort and time committed by academics to teaching each degree objective given in the Attribute Spectrum. It provides a rough measure of the exposure and potential for learning that students have for each degree objective. Figure 4 provides the "output", the average percentage of the final mark, which gives an indication of the extent the assessments address the degree outcomes within the attribute spectrum. A rating of "0" signifies the outcome is not covered while a rating of "3" signifies the attributes of the outcome were a major focus of the unit. Figure 4-2 is a brief interpretation of the data analysed for the programme in 2009.

The data were collated and averaged for each of the years of study (years one to four). The graphs generally provide quantitative evidence that all of the degree objectives are being taught (see Figure 4-3) and assessed (see Figure 4-4). Due to the alignment between the AMC engineering objectives and EA competencies, these graphs provide evidence that the degree is meeting requirement stipulated by the latter and that students are taught and assessed against each of the competencies. The graphs demonstrate that students are exposed to and assessed on these skills in most years during their undergraduate experience.

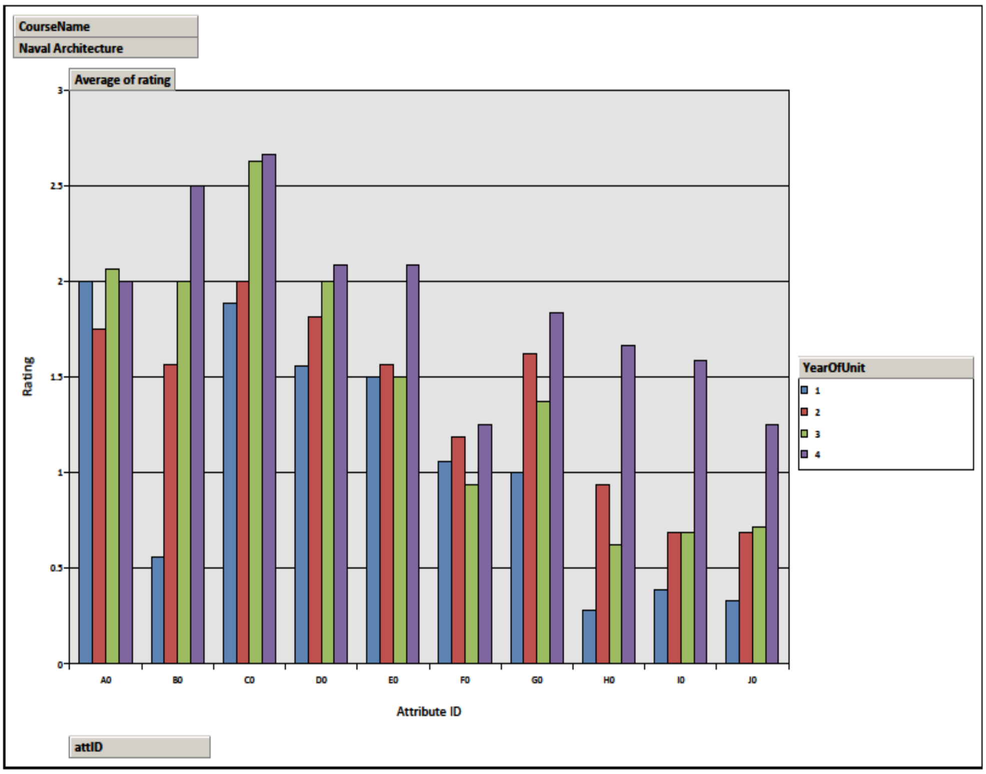

Figure 4-2 Average teach rating for the BE (NavArch) against the course outcome.

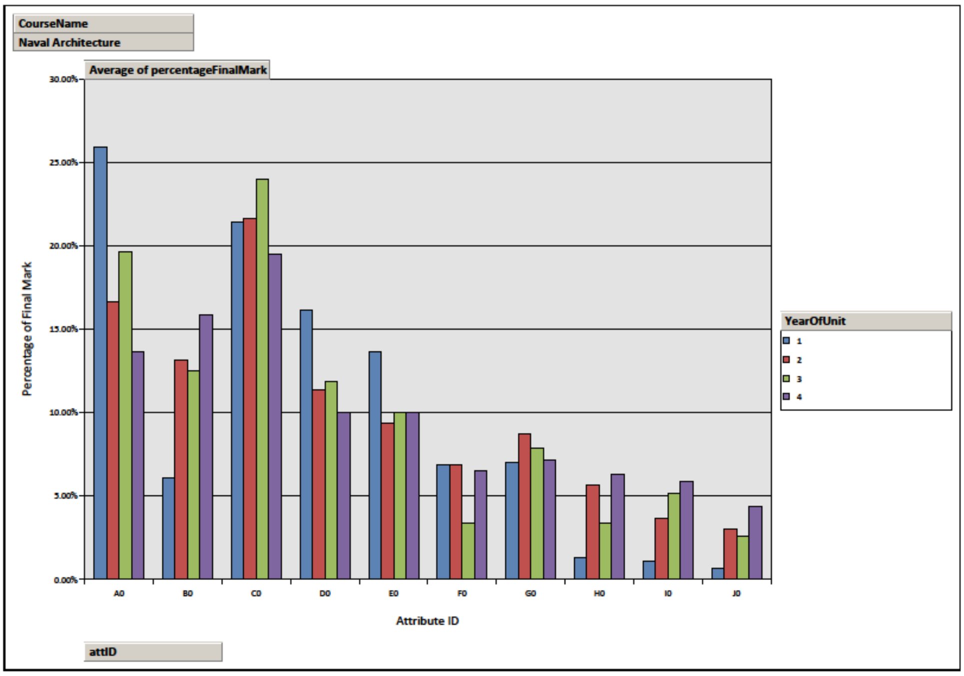

Figure 4-3 Average percentage of final mark for the BE (NavArch) against the course outcomes.

The general similarity in profile between teach rating graph (see Figure 4-2) and assessment percentage graph (see Figure 4-3) shows good alignment between teaching emphasis and two important artefacts of assessment: student motivation and course quality assurance for graduate attribute teaching and learning.

Figures 4-2 and 4-3 show the strong emphasis that the Naval Architecture degree has on technical and engineering science fundamentals, design and problem-solving in that all graphs show strong and consistent emphasis on degree outcomes A (technical knowledge), B (design) and C (problem-solving). It should be noted that the latter two (B and C) encompass a broad conceptualisation of these two activities and thereby subsume some “soft” or generic skills (see the previous section for the degree outcomes).

The figures also demonstrate that the degree is providing students with solid grounding in fundamental skills of D (information management), E (communication), F (teamwork) and G (self/other management). Although the soft skills H (business environment), I (professionalism) and J (wider context) are taught across the degree, their assessment tends to be low.

It is possible that the mapping approach may have been ill-equipped to capture indirect and out-of-class type activities that develop students’ skills in these areas and, thus, need improvement. However, this information was used to develop and enhance the delivery and assessment of the relevant attributes.

The attribute spectrum and the collection of the data through the database were developed and introduced during 2008 to 2009. Thus, the quality of the data and analysis will depend on improvements to the model and the relevant tools, as well as providing staff with the time and training to familiarise themselves with the concepts and systems.

4.5 Delivery and Attainment of Competencies: An Exemplar

Students engaged in active learning are able to assimilate information at their own pace, as well as allowing the facilitation of learning in students who might otherwise be disadvantaged. All units within the AMC maritime engineering degree programmes attempt to relate back to maritime practice, thus, providing examples and problems linked to the industry. During subsequent years, the students build on the fundamentals to develop their knowledge and skills in their area of study.

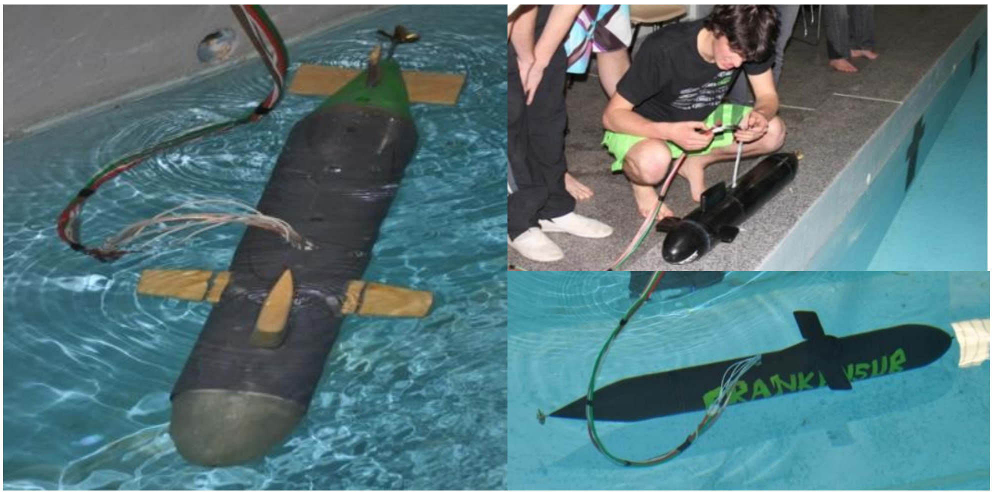

Figure 4-4 Testing of the model submarine.

The submarine project (see Figure 4-4 above) introduced in the second year Fluid Mechanics unit is an example of a project providing realistic and challenging tasks, promoting interactive and holistic problem-based learning that links the relevant theory to practical work.

The project spans a whole semester and is undertaken in groups consisting of six to eight students allocated from all degree programmes. They are required to design, construct and test a model submarine to meet design and operational specifications. The group submits a final report comprising of:

(1) Project plan, resource allocation and variances;

(2) Description of the design, including CAD (computer aided drafting) drawings, tables and graphs;

(3) Supporting literature survey, assumptions, theory and calculations;

(4) Testing schedule and results;

(5) Conclusion and recommendations; and

(6) Description and percentage of work carried out by the team members.

The submarine project is used below as an example to clarify how a project addresses each of the 10 course outcomes. The discussion under each heading explains how the contents are delivered and the outcomes assessed (through a predefined CRA). The information is not separated into the underlying attributes; rather they address the outcome in a holistic manner.

Outcome A—Demonstrate Technical Knowledge

The assessment tools, wherever possible, are linked to actual problems, with students required to apply industry standards and practices to their solutions. They are encouraged to look for options and solutions from industry.

Submarine project. Given that the submarine itself is designed from minimal information (nonprescriptive), the solutions generated by the students are unique, effectively creating a barrier against plagiarism, while promoting design and innovation. Students are required to integrate the technical knowledge gained from other units to successfully complete the project.

Outcome B—Design for the Maritime Environment

Design is embedded within most projects, with students introduced to the concepts and required knowledge early in the relevant units.

Submarine project. The students are given a design brief for the submarine and are required to design a workable system to meet those specifications, using industry standards and practices, and importantly common sense, an attribute that tends to be frequently overlooked. The design must be supported with adequate and accurate calculations, clearly stating the assumptions made during the process.

Outcome C—Solve Maritime Engineering Problems

This is embedded across the three-degree programmes, gradually building on the knowledge and skills acquired during the study programme. Students are given engineering problems which require them to identify the requirements, constraints and the "tools" required to solve the problems. The latter is an area that students need substantial support to develop, as most students find it difficult to decide on a solution approach. The problems attempt to make students identify logical patterns and pathways to take in their quest to solve the problems, rather than taking a "scatter gun" approach or trying out a haphazard mix of solution techniques with the hope that one will work.

Submarine project. Students are required to identify various operational conditions peculiar to submarines, such as stability, internal and external forces and structural integrity, including making drawings of the vessel and related systems. They then carry out calculations which include stability, pressure, drag, lift, thrust and power to identify limitations, failure and vessel dimensions, relating them back to their drawings.

Outcome D—Manage, Create, Use and Disseminate Information

These skills are introduced and developed through integrated activities throughout the programme. Although exposed to new technology, they are not always sure how to access information, efficiently sort and store them, and present them in a suitable high impact format. The approach was to provide appropriate tasks requiring these skills and guide them using a combination of instructions, examples and mentoring.

Submarine project. The design brief required the students to search for information through a number of avenues, including references, publications, Internet and discussions with external sources. The project is heavily dependent on the students to collectively and individually acquire information from a range of sources, and their abilities to sort the data into different categories depending on their speciality, relevance, currency and quality. They are required to maintain evidence in the form of design files and work plans that are all assessed. Given the magnitude of the tasks, it is important that the teams manage the information in a logical format and maintain controlled documents.

Outcome E—Communicate Effectively

Communication skills are developed and assessed across the programme through a range of presentations. However, greater focus is now placed on informal communication, group dynamics and internal and external stakeholders, achieved through group projects and industry links, with the outcomes of these ventures and, thus, the assessments, dependent on these skills.

Submarine project. The project requires the teams to provide a complete preliminary design, including supporting documents in line with industry practice. The students are required to source information through a number of avenues, which include communicating with internal and external personnel. They are required to provide continuous updates on their progress, including the use of project management tools, culminating in a final report. The relatively large size of the group requires the members to maintain good communication links within the group to ensure success.

Outcome F—Work in Teams

Introduction to teamwork commences right from the beginning through group activities and assessments. Students are required to work within teams to carry out investigations and provide group reports on their findings and results. Students must manage and distribute the workload between the team members.

The groups are allocated by the lecturers rather than allowing like-minded students to form groups, requiring them to actively work on building good team dynamics with students from different backgrounds and nationalities. Team-based projects require teamwork and leadership to ensure success with individual contributions assessed.

Submarine project. The teams have to conduct regular meetings, keep records and monitor their progress. Although the overall timeframe is dictated by the unit outline, the internal time and resource allocation is carried out by the team and its leadership, which requires acceptance by all to ensure success. The team members should also deal with conflict resolution, although instructors will provide assistance if required. The assessment includes peer-assessment that is depended on group dynamics and contributions.

Outcome G—Manage Self and Others

AMC have steadily moved towards more student-centred learning, with the students required to manage and take responsibility for their work, essential for successful learning. Group projects require students to manage team work, including the allocation and management of team resources and personnel.

Submarine project. The project is open-ended and deliberately lacks sufficient information for a straightforward solution. The students have to investigate the design requirements to fill in the gaps, before moving on to the solution. The latter requires an iterative approach, generating additional input and further investigations. Given the depth and breadth of the task that is carried out within normal semester time, students are required to manage their time and workload to meet the required outcomes. To ensure success, the team has to assist and mentor each other in areas of their speciality, as well as managing the collective efforts of the group. The assessment includes peer-assessment, where students assess the contribution of all members, which is included in the final grade.

Outcome H—Negotiate the Business Environment

Most projects are carried out to a design brief and are subjected to all commercial requirements. A number of projects are linked to industry, requiring students to liaise with relevant industry partners.

Submarine project. To enable students to achieve these outcomes, a number of lectures, including those by technical and non-technical professionals from related industries and organizations, are provided. These introduce new concepts, expand on current knowledge and provide forums for discussions on relevant areas. Students also research and obtain information from various internal and external sources on commercial operating principles and procedures.

Outcome I—Behave as a Professional

Throughout the programme, students are introduced to the ethics, practices and responsibilities of professional engineers. As a number of these projects are linked to industry, students have to communicate with partners and stakeholders from industry and the wider community. All relevant projects must conform to and are assessed against environmental requirements.

Submarine project. Given that the project requires construction and testing in a freshwater pool of sufficient depth to ascertain the submarine's diving ability; identifying and adhering to all relevant safety and environmental issues are essential and assessed. Given the nature of the issues, staff members continuously provide advice and assistance as required. Students are also assessed on their professionalism during the project, especially when working within their team.

Outcome J—Consider Wider Context of Engineering Knowledge and Work

Students are constantly exposed to both technical and non-technical issues that affect their careers, their profession and the world at large. Guest lectures, student excursions and industry linked activities/projects provide students with an insight into non-technical aspects and examples on how industry operates within a global environment.

Submarine project. The project is assessed for technical content, innovation, feasibility, suitability, environmental impact, maintenance, etc. and as such the students are introduced to regulations, equipment and procedures within the maritime and related industries to protect the environment, e.g., the prevention of marine pollution from vessels at sea. This includes incorporating them into the design and construction work. Students are also exposed to embedded lectures by qualified industry and related professionals during the project.

4.6 Conclusions

Gone are the days when academic institutions concentrated purely on the technical contents when developing, delivering and assessing engineering degree programmes. Industry and accreditation bodies insist that the programmes not only meet both the technical and generic attributes but also show that the graduates have attained these attributes. An approach taken by many institutions was to "append" the generic attributes to the course curriculum in the hope that they would be covered during the delivery and assessment processes that tended to concentrate on the technical contents.

AMC has developed an integrated approach that describes the objectives, outcomes and attributes as a continuum defined as an attribute spectrum. This clearly defines the attributes the graduate will possess at the end of their programme and provides a basis to build unit delivery and assessment tools that meet all of the required learning outcomes. The size of the resulting attribute spectrum required a rethink on how to meet all attributes within the given time span and resources, which led to the development of a series of problem-based holistic practical group projects across the programme, that addressed multiple technical and generic attributes. The success of these projects was made significantly easier by the use of the attribute spectrum that allowed the targeting of the relevant attributes and the development of the required CRA. In essence, the use of projects within the assessment model enabled a holistic approach to assessment, which provides a specific measure on how well the students have met the graduate attributes through explicit learning outcomes that are grouped into specific statements on what the student will be able to do as a result of the project.

Parallel with this development is a practical and simple method of tracking and quantifying the achievement of the attributes. It enables the institution to track various delivery and assessment processes linked to the attributes, yielding useful data to improve the quality of the programme and hence, the graduates. Although the current system tracks cohort of students, it is intended to update the system to track attributes attained by the individual students.

The industry is continuously evolving to meet changing world demands and practices. Thus, the programmes themselves have to change to remain viable and relevant to the industry, community and the students, while meeting the requirements of accreditation bodies. The process and tools described in this paper provide an efficient system to develop, track, update and modify the programmes to ensure relevance and quality.

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CHAPTER 5 Peer Assessment of Graduate Attributes in Problem Based Learning: A Systematic Review.

Development and Assessment of Graduate attributes

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"STUDENT PEER ASSESSMENT IN ENGINEERING PBL EDUCATION: A SYSTEMATIC REVIEW"

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Abstract

Problem-based learning (PBL) with its roots in health education has been adopted by many including engineering educators. In today's employment environment, graduates have to prepare themselves to become self-managed lifelong learners. To facilitate this, higher education (HE) engineering institutions have employed PBL as a means for students to develop awareness of learning as a process and emulate real world multi facet problems to attain the required graduate attributes (GAs). At the same time, peer assessment has proven to be an effective educational assessment intervention within the PBL environment.

This paper reports a systematic literature review examining empirical studies on the use of peer assessment in PBL. The review and analysis of the literature search presented focuses on empirical studies on measuring the attainment of graduate attributes using peer assessment in PBL. A systematic literature review was undertaken using major bibliographic databases including ERIC, JSTOR, Journal TOCs and INSPEC including all available inclusions from January 2001 to July 2014.

This review aims to give an overview of the use of peer assessment within the PBL environment in the assessment of graduate attributes, and attempts to answer the question; "Is peer assessment a valid and reliable assessment technique for assessing graduate attribute development through the use of Engineering PBL?"

Literature has shown that peer assessment adds to student learning if implemented in a structured and constructive way, but little work is evident in the area of the use of peer assessment in measuring the attainment of graduate attributes, and the implied impact of student variables when assessing their attainment.

Although peer assessment is an effective educational intervention within PBL, questions were raised as to the validity and reliability of using the peer assessment instrument when assessing

GAs. Such an instrument can only be justified by evidence of its sufficient reliability and validity as well as the discriminative purposes of the assessment. This review has clearly demonstrated that student variables may have an impact on the outcome, validity and reliability of peer assessment.

5.1 Introduction

Problem and project based learning (PBL) is a learner-centred, constructive educational method with its roots in the health educations system (Engel, 1991). Over time, higher education (HE) fields such as engineering have adopted this method with some arguing it has been one of the most important developments since embedding professional practice into education programmes

In today's employment environment graduates have to prepare themselves to become self-managed lifelong learners, to ensure on going employment success. To facilitate this, higher education institutions have employed PBL as a means for students to develop awareness of learning as a process and emulate real world problem solving to develop graduate attributes (GAs).

In engineering undergraduate education, PBL has become common practice. Usually undertaken as group work, PBL is reported to encourage deeper learning, and promote student autonomy. Stewart and others (2012) found that students acknowledged that deep learning and team work skills are essential if they are to be an effective engineer. Team work has many benefits for a student's professional development but it is difficult to determine individual contributions to group assessment tasks. The challenges arise due to the focus of the pedagogy being primarily 'on learning to learn' rather than the mastery of content knowledge. As Major (1999) argues, traditional methods of assessment such as exams may not be very effective when assessing GAs in PBL. Hence, PBL introduces some unique challenges with respect to assessment.

5.2 Assessment

Assessment currently appears to be one of the most controversial concerns in PBL (Savin-Baden, 2004). Typical statements in text books on teaching in higher education state "Assessment is at the heart of the student experience" (Brown and Knight, 1994:1) and go on to state that the assessment system has a profound influence on student behaviour and the learning environment. Research has shown that student behaviour and student learning are shaped to a large extent by assessment (Black & Wiliam, 1998; Bould, 1990; Ramsden, 2003; Scouller, 1998; Thomas & Bain, 1984) and that assessment to a large extent drives student behaviour and motivates learning (Black & Wiliam, 1984; Ramsdon, 1992, Havnes, 2002). From the students' point of view; assessment defines the curriculum (Ramsden, 2003).

One of the advantages of PBL is that it calls for the use of authentic practical assessment (Erdogan & Bozeman, 2015). A well designed PBL project with continuous assessment throughout the project ensures that the students are getting the stated knowledge and skills, which are not only needed to complete the project but also to ensure that processes and outcomes are developed in group project work. This type of assessment is much closer to how work done in the real world, outside of the education environment, is evaluated.

Traditional and authentic assessment methods can be used to measure content knowledge developed during PBL, workflow, solutions, documentation, and implementation (e.g. The Product). In PBL, formal assessment can take place at specific points within the project timeline. The assessment of the product is easily accessible by adopting methods that determine a grade against a standard using predetermined criteria. But it is also required to identify what assessment methods are most appropriate for PBL's 'spin off' learning: process management, development of personal transferable skills, problem-solving, leadership, communication. These are all associated generic attributes that PBL can effectively evaluate, which is more difficult to assess in traditional academic environments, especially as much of this process learning is undertaken outside the class room.

5.2.1 Peer Assessment

The use of peer assessment in PBL has gained significant ground as a means of fostering student accountability and responsibility for group projects in higher education (Neus, 2011). It is generally accepted in engineering education that a programme of assessment incorporating an element of peer assessment, in some form, is beneficial to learning (Falchikov and Goldfinch, 2000). Specific benefits cited includes, (Cassidy 2006, p. 509):

- increased student responsibility and autonomy;
- evaluative skill development;
- insight into assessment procedures and expectations for high-quality work;
- students work harder with the knowledge that they will be assessed by their peers;
- potential for providing increased levels of feedback without increasing demands on tutors (Walker, 2001); and
- encourages deep rather than surface learning (Brown & Knight, 1994).

However for peer assessment to be successful in assessing graduate attributes developed during the PBL process, it must provide valid and reliable evidence of their attainment. For assessment data collected to be **valid**, it must assess what it claims to assess, and to be **reliable** it must provide evidence that can be repeated (Carmen & Zeller, 1979). In the context of using self and peer assessment in PBL, these measurable characteristics are further explained below.

- **Validity:** Group-based assessment, such as PBL, can extend the range of assessment to include cooperative and collaborative skills, effective teamwork, communication, and so on, and increase assessment validity by bringing into the assessment framework skills, competencies, and attributes which are more closely connected to real-life industry-related situations than are the traditional exams and essays. Peer assessment can be seen as a highly effective process in assessing these areas, but for it to be valid it must demonstrate the relationship between the concept it wishes to measure and the context it is used in.

- **Reliability**: Both student self-assessment and student peer-assessment can increase the reliability and objectivity of assessment, by making assessment decisions and grading's less dependent on the judgments of a single assessor, and exposing the extent of possible inter-assessor unreliability. Clearly, for self-assessment and peer-assessment to work well in such respects, they need to be demonstrably objective and fair, and appropriate moderation needs to be in place to assure this. Group-based assessment, while contributing strongly to extending the validity of some kinds of assessment, it may be seen as less suitable for assuring the reliability of assessment.

Savin-Baden (2004) contended that assessment is one of the most controversial issues in PBL as its importance as a predictor of the effectiveness of student learning. Race (2001) lists the main factors supporting the adaptation of peer assessment, which includes: its inherent capacity to catalyse deep learning in students' approaches to learning, develop self-evaluation skills, and insight into their own performance. Peer assessment of an individual's contribution to group work can be used to encourage student participation, overcoming the problem of 'free riders'. Slauijsmans (2002) discusses the benefits in students making an active contribution to their own knowledge construction by being personally involved in the assessment process, which contributes to their attainment of learning outcomes.

Peer-assessment is a common form of shared learning in which students provide feedback on each other's work. It improves the quality of learning and empowers students (McDowell and Mowl, 1996). Skills such as effective communication, behaving professionally, being organised and effective team work is assumed by merely participating in PBL activities. However, little research is evident with regard to the assessment of a student's attainment of 'soft' or industry required skills in PBL. Self and peer assessment processes are adopted in PBL to evaluate the effectiveness of individuals functioning in the group environment (Topping, 2003).

All assessments should be fit for their purpose and as with any assessment; its purpose is the key component in determining its reliability and or validity. The quality of assessment can be influenced by a variety of factors, for example, peer interaction, comfort in assessing peers, interdependence, and friendship bias (Sluijmans et al. 2001).

When introducing performance assessment in group work, we need to ask whether observations of complex behaviour can be carried out in a credible and trustworthy manner. Topping (2010) stated that there is more work needed in exploring the impact of variables on the outcome of peer assessment. This problem is most pressing for high-stakes assessment such as final design reports which contribute significantly to the students' final grade. Institutions using peer assessment in PBL for high-stake decisions are thus faced with the challenge of showing that these assessments are both valid and reliable. The higher the stakes associated with assessments, the greater the requirement for validity evidence from multiple sources collected on an ongoing basis and continually re-evaluated (Linn, 2002). Institutions using peer assessment in PBL for high-stake decisions are thus faced with the challenge of showing that that peer assessment is both valid and reliable.

With our strong and central use of teamwork for learning and the corresponding use of peer assessment, there is a need for a better understanding of the reliability, validity, and possible bias in peer assessments of students working in these interdependent, self-directed, problem-solving teams. This review focuses on the specific problems of the reliability, validity, bias, and user acceptance of peer evaluations within PBL teams (Topping, 2003).

5.3 Research Question

This study aims reviews the practice of PA within the PBL environment in the assessment of graduate attributes to answer the questions:

- Is peer assessment a reliable assessment technique in assessing graduate attributes in Engineering PBL?
- Does peer assessment provide valid evidence about students' attainment of graduate attributes?

5.4 Method of analysis

This paper is based on a systematic literature review to scope and critique the research on the use of peer assessment for supporting and measuring attainment of graduate attributes within a PBL environment. The review was designed to evaluate whether peer assessment is a valid and reliable tool to assess the attainment of graduate attributes.

In order to recover relevant articles which use peer assessment in relation to PBL, a literature search in the following electronic databases was undertaken (Table 5-1): ERIC, SpringerLink, informit and JSTOR. All available inclusion dates up to the 25th July 2014 were searched, although they were limited to English publications. Thesaurus terms were supplemented using free text words (truncated or wild card) to identify the most relevant publications over the past fourteen years.

Only articles describing the use of peer assessment in PBL settings were included in the selection of papers for analysis. Articles describing the use of peer assessment as a method of evaluation on attainment of learning outcomes, graduate attributes, and employability skills, as well as those articles presenting data about the reliability, validity, and/or interpersonal variables, were included in this study. Studies about the use of peer assessment tools, peer rating of individual work as defined by Raban & Litchfield (2007), were deemed outside of the scope of this research and were excluded from this study. Finally, the citations listed in the six selected papers were searched for additional literature, with a further 32 articles identified for further analysis in order to answer the research questions.

Table 5-1 Systematic literature database search

	Literature database	Abstracts identified N= 195	Search Terms	Limits (inclusions dates; type of paper)
Thesaurus terms	ERIC JSTOR SpringerLink Informit		Self AND Peer assessment AND problem-based learning AND reliability and validity	
			Peer assessment AND Graduate attributes	
			[AND] peer review graduate attributes	
			Peer assessment AND Employability	
Free text words (truncation or wild card)			Engineering education or Engineering problem-based learning	Article Proceedings, Paper
				January 2000 to present July 2014)

5.5 Results

The combined searches of thesaurus terms plus free text words in four databases listed in Table 5-1 yielded a total of 195 articles. From these, a total of 32 articles were reviewed having met the inclusion criteria, with some drawn from the references listed on searched papers. In this study, a narrative review of the literature was used, which requires careful reading of the individual studies and integration of the findings contained within them. For each paper, the following data was summarised based on the reviewed article:

- number of participants;
- study settings;
- subject of the peer assessment; and
- discipline and summary according to the authors of the articles.

The literature on self and peer assessment was observed to fall into three broad categories in terms of:

- their use as an assessment tool in PBL;
- enhancing learning through formative and summative feedback; and
- practices and meanings of power.

The common denominators of these three categories are that there is a degree of student involvement, and this involvement takes the form of making judgements concerning learning objectives and contribution to team work. Table 5-2 (Appendix A) presents an overview of the included articles identified in this review.

From the 32 articles reviewed, six were judged as highly relevant to addressing the research questions. The following sections consist of an in-depth critical review of the six articles as judged as key to this study, and the possible insights each imparts on the validity and reliability of peer assessment for evaluating student GA learning in PBL in Engineering.

5.6 Overview of studies

The combined searches of thesaurus terms plus free text words in four databases yielded a total of over 2000 articles. From these a total of 32 articles were reviewed having met the inclusion criteria, some drawn from the references on searched papers. Table 2 presents an overview of the included articles. From the 32 articles reviewed 6 were considered as relevant to addressing the research questions.

For each study, the following data are summarised based on the original article: number of participants, study settings, subject of the peer assessment, discipline and summary according to the author. The literature on self- and peer - assessment may be understood as falling within three broad categories – in terms of their use as an assessment tool, in terms of enhancing learning, and in terms of practices and meanings of power. The common denominators of these three are as is that there is a degree of student involvement, and this involvement takes the form of making judgements concerning their learning.

To date, the majority of peer assessment studies have collected students self-reporting of learning in peer assessment practice (Strijbos and Sluijsmans, 2010). Little has been done to investigate the impact of student variables on the validity and reliability of peer assessment in engineering PBL. Topping (2010) stated there is more work needed to be done in exploring the impact of variables on the outcome of peer assessment. What follows is a summary of each study, the possible impacts on validity and reliability will be reviewed.

5.7 Evaluation of the studies

Sluijsmans, Moerkerke, van Merrienboer, and Docy (2001) focused on the introduction of peer assessment in PBL, exploring the answers to three questions:

- Are peer ratings in PBL groups reliable?
- Do students have idiosyncratic (i.e. personal) strategies in peer assessment?
- What are students' experiences in peer assessment and PBL?

Two studies were carried out by the authors (labelled Study I and Study II). Study I focused on of 27 university students (9 male, 18 female) enrolled in a four-year educational science degree that was using PBL. The 27 students were divided into two groups (n1=13, n2=14), where all students assessed their peers in their group based on four criteria: (1) contribution to group discussions, (2) quality of the contributions, (3) preparedness to be involved in the tasks, and (4) contribution to group work. These criterions formed the framework in developing a two part evaluation questionnaire. The first part consisted of 28 five-point Likert scale items focusing on different aspects of PBL (working in teams, problem-solving, and the learning process). The second part consisted of eleven items about peer assessment, seven yes/no items and four open-ended questions. The two groups worked on four six week long problem tasks.

Study II consisted of 51 higher vocational education students (13 male, 28 female) enrolled in a four-year primary school qualification. The 51 students were randomly distributed into four groups (n1 = 12, n2 = 13, n3 = 13, n4 = 13). All the students were peer assessed against the same four criteria given in study 1. Scaling against these criteria was based on a positive contribution yielding a positive score and vice-versa.

The same peer assessment and evaluation process was used in both studies, generalizability theory is a statistical framework for conceptualizing, investigating, and designing reliable observations. It is used to determine the reliability (i.e., reproducibility) of measurements under specific conditions used in this study to assess the reliability of the student ratings where Q-analysis was used to interpret personal strategies, by using inter-rater correlations as similarity measures.

This study revealed that students, in general, did not feel comfortable rating their peers negatively and interpersonal relationships were biasing the peer assessment. The two areas of particular interest to the authors were the results to question 1, Are peer ratings in PBL groups reliable?, and question 2, Do students have idiosyncratic strategies in peer assessment? on idiosyncratic strategies. Results to question 1 raised some questions on validity but was inconclusive and one should question the method used, given it did not allow discrimination between those that had experience in peer assessment and PBL and those that did not. The research confirmed the impact of friendship bias, collaborative or individual dominance in the scoring process. It can be inferred that undertaking peer assessment by scoring alone is not enough and students must be given opportunities to develop experience in making a reliable judgement.

In summary, the research did reveal the importance of feedback, in particular, in-direct feedback and provision of adequate training in peer assessment embedded in the course domain. The study did highlight the need for clear definitions with respect to the criteria and its context, while students needing an understanding of constructive feedback that is understood by the peer.

Van Gennip, Segers, and Tillema (2009) reviewed studies on the effect of peer assessment on learning, taking into account the role of interpersonal variables and structural features influencing peer assessment. As interpersonal variables, the authors identify psychological safety, value diversity, interdependence, and trust. Psychological safety is defined as the perception that it is safe to take risks among peers. Value diversity can be described "as a difference in opinion of what a team's task, goal, or mission should be (Van Gennip et al., 2009, P43). With regard to interdependence, the authors differentiate between outcome and task interdependence. Outcome interdependence is seen as the belief of team members that their personal benefit depends on the success of the team, while task interdependence refers to the connectedness of the subtasks that make collaboration necessary. Trust was defined as the confidence in oneself to rate others fairly and to provide constructive feedback. In addition to the interpersonal variables, the authors identified structural features of peer assessment. These were grouped in three clusters:

- assessment description including the purpose, outcomes, place and time of the assessment;
- the interaction, i. e. the directionality, privacy and kind of contact; and
- the composition of the feedback group, e. g. across different years of studies, abilities, and the number of people assessed

The main research question of the article was, "To what extent are the outcomes of peer assessment on learning related to interpersonal variables, and to structural features of the peer assessment format?" (p51)

The study by the authors was conducted as a literature review based on a sample of 15 articles, which were listed in the paper. They range from 1991 to 2006 and included various research designs. The studies were critiqued with regard to interpersonal variables and structural features.

In terms of interpersonal variables, only four out of the 15 studies reviewed by Van Gennip et al. include interpersonal processes as variables under study. Among the studies reviewed, value diversity and interdependence did not appear as variables at all, psychological safety was mentioned in one study while trust was mentioned in three studies.

In summary, the article aims at disclosing the effect of peer assessment on learning from a social perspective. However, the selection of interpersonal variables seems quite random. It is based on three studies which are closely connected through referencing. However, it not clear why these interpersonal variables and not others (e. g. cohesion of the students, interdependence) were chosen. The strength of this study, however, is the introduction of these variables.

Van Zundert, Sluijsmans, and Van Merriënboer (2010) reviewed the literature on current research on peer assessment in higher education. The review focused on literature published between 1990 and 2007 that were: published in a journal, consist of an empirical study, and focused on peer assessment between students in an educational setting. The resultant search returned 26 articles. Analysis of the literature resulted in four categories being identified:

- psychometric qualities of Peer Assessment;
- domain specific skill;
- peer assessment skill; and
- students attitudes to Peer Assessment.

The findings of psychometric qualities of peer assessment were found to be diverse and reported in several ways. However, there was correlation between experience and the number of exposures to Peer Assessment. Domain specific skills related to the quality of the students work, for example writing performance or technical homework assignment. Overall, the study suggests that enabling students to revise their work on the basis of peer feedback, small group size, and specific feedback format, had a positive influence on domain specific skills. Peer Assessment skill related to the training and or number of times a student has been exposed to Peer Assessment. The findings show that Peer Assessment skill is improved through the appropriate use of training and the identification of the student's specific thinking style. It was shown that students with higher executive thinking styles were generally better at assessing than those that demonstrated lower executive thinking styles.

Student's attitude to Peer Assessment revealed an overall positive attitude to Peer Assessment. It is notable that a number of instruments used to measure student attitudes were used in the studies. It was noted that male students appear to have a more positive attitude to Peer Assessment than female students. As the studies in this review looked at learning outcomes over short time scales, the effects of Peer Assessment over longer-term outcomes merit investigation.

In summary, the review revealed that although the training and continual practice improved the reliability and validity of peer assessment, the effect depended on the students thinking style and academic achievement. It also depends on whether the assessment is reciprocal, which impacts the trust and psychological safety of the peer relationship.

Ohland, Layton, Loughry, and Yuhasz (2005) focus on the effects behavioural anchors have on the inter-rater reliability of three peer evaluation instruments. The first a single-item instrument without behavioural anchors, the second a ten-item instrument, and the third a single-item behaviourally anchored instrument. The primary assessment was on rating contribution to teamwork, for example, attending team meetings, takes responsibility seriously, completes tasks on time, and communication skills. Three peer evaluation instruments were compared over four years with junior-level engineering students. The three instruments (Forms A, B, and C) compared in this study were paper based and required students to rate each team member's contribution to a project. Two instruments required both peer and self-assessment and one required only peer assessment. All three instruments were administered twice during the project, once within the first five weeks of the project and the second at the end of the project. Students were provided formative feedback on the first administration of the instrument study however only reported on the results from the summative assessment results.

The authors administered the instruments over a four year period with the instruments being labelled Forms A, B and C. Forms A and B alternatively over three years and Form C in year four only. The team sample for Forms A and B consisted of 21 teams, one all-female team, 11 all male teams, and 9 mixed-gender teams. The team ethnicity was 12 all minority teams and nine mixed ethnicity teams. The team sample for Form C consisted of 17 teams, 11 of whom were all male and six of mixed gender. The team ethnicity was 11 all African American minority teams and 6 mixed ethnicity teams.

The study administered a nested single factor G-study design method, which investigates how well the sample of measurements can be generalized to all possible measurements (p322), to analyse the data to calculate the generalising coefficient.

Form A had the students rate the overall contribution of each student using one-word descriptors out of the provided nine-word list. Students using Form A were provided with training. Forms B and C asked the student to rate against between six – ten rater attributes of different aspect of team contribution. Form B had the students' rate against team attributes using a five point Likert scale ranging from "unsatisfactory" to "excellent". Form C differed from Forms A and B in that it gave nine behavioural anchors for each rating used to assess the attributes. The author's point out that by adding behaviour anchors and descriptive instructions to peer assessment instruments, it significantly increases the reliability of the instrument, with a generalisation inter-rater reliability coefficient of 0.78. It is interesting to note that when comparing the number of student raters using Forms B and C, the reliability coefficient differential decreased significantly when raters were increased from four to five students.

In Summary, the study did show some increase in reliability of inter-rater scores when using Form C. The paper did bring into question the impact of rating bias by friendships, popularity, jealousy, or revenge and as such did conclude conservatism in the results, in particular when questioned on the validity of the instruments. Further studies might examine the impact of including or excluding self-ratings with regards to the reliability of the instruments.

Thompson (2001) focused on the use of generalisation theory (G theory) to investigate the validity of peer and self-evaluation in directed interdependent work teams. The study set out to answer two questions:

- Are interpersonal perceptions on self-directed interdependent work teams biased or can they be used as a reliable and accurate source of information for feedback to peers working together on group projects?
- Are self-evaluations a better source of measuring the accuracy of team skills

The study involved 49 students in a multidisciplinary senior capstone design course, where the students worked on two major design projects each over six to seven weeks in duration. Ten teams were formed for each project, nine teams with five members and one team with four members. Student relationships had formed over a two year period. Each team were assigned an open ended problem where students were to define specific objectives, a plan, and schedule their work to meet pre-defined deadlines.

A round robin research design was used to analyse the peer assessment data. Two confidential peer assessments were conducted for each project. Behavioural anchoring rating scales were used in the peer assessment process. The students self and peer assessed eight-team skills, where the teaching team observed, for the purpose of assessing fairness, individual contribution, technical knowledge, and effort applied to the project. The correspondence between the criterion measure (set in previous work by the author) and the ratee effect were used as the measure of validity. Confidential peer feedback was given at the mid-point and the end of the project through review sessions.

The research showed a high correlation between self-evaluation and the criterion measure, interpreted by the author as confirming that peer and self-evaluation is a valid measure. The high values reported were attributed to the training, the inclusion of behavioural anchors and the relatively long periods of acquaintance of each team member. However, the validity of self-assessment was reported as low, this was attributed to the fact that students tended to rate themselves better than others within the team.

In summary, this research demonstrated that peer assessment is a valid method for improving team work and assessing the associated skills. It did report that the validity of self-assessment in measuring truth or accuracy of team skills is low and attributed to individual traits. It concluded that training and formative feedback attributed to improving the validity of peer assessment

Zhang, Johnston, and Kilic (2008) this research used generalisation theory (G theory) to evaluate the reliability of self and peer rating of group work in terms of the degree of consistency between students themselves, as well as group and rater effects. Four research questions were proposed in the paper:

- How reliable are self-and peer ratings from group work?
- To what extent does the inclusion of students' self-rating affect the reliability of peer and self-ratings?
- How large are the group effect and rater effect?
- How reliable are the ratings on specific contribution indicators, such as motivation and communication?

Two studies were undertaken with data from two sources, Study 1 using data from Bagci Kilic and Cakan (2006) and Study 2 using data from Johnston and Miles (2004). Generalizability Theory (G Theory) was used to evaluate the reliability of student ratings using self and peer assessment. The two indicators, group work effort and academic contribution, were investigated.

Study 1 consisted of 134 students distributed across three classes. The first consisted of 39 students was divided into nine groups, the second 30 students divided into eight groups, and the third 26 students divided into eight groups; with the students allowed to select their own groups. The study only reports the results of those groups that had fully completed peer and self-assessment requirements, with a mean cohort contribution of 49%. The six indicators (1) motivation/responsibility/time management, (2) adaptability to other team members, (3) creativity, (4) communication skills, (5) general team skills, and (6) technical skills were assessed based on an analytical scoring rubric using a six-point scale (Bagci Kilic and Cakan, 2006). Indicators 1,2,4 and 5 reflected the student's engagement in group work effort with 3 and 6 reflecting the level of academic contribution.

Study 2 consisted of 61 undergraduate psychology students in one class divided into 15 groups, with the groups ranging from three to five members. This differed from Study 1 in that only peer assessment was used to provide a group score and assessment was based only on the academic contribution indicator of the group work. Ratings were based on an analytical rating scheme that included seven indicators from Johnston and Mule (2004) of an individual's academic contribution, although the seven indicators were not provided.

In summary, the paper sets out to utilise G theory to evaluate the reliability of student ratings in self and peer assessment in terms of the degree of consistency among students, and group rater effects. The findings of this study suggest that a strong group effect (variability in scores) exist. Although the study highlighted some general trends in the reliability of self and peer assessment, further investigation is warranted into the effects of the individual over group scoring. The difference seen between the two studies conducted was the self-rating effect, which resulted in a negative impact on the reliability in Study 2, a finding consistent with that of Ohland, Layton, Loughry, and Yuhasz (2005). Other possible areas of future research are to investigate what variables are associated with how groups are formed and students' interpretation of contribution to group work.

5.8 Discussion

This review set out to determine as to whether peer assessment is a valid and reliable assessment technique in assessing graduate attributes in Engineering PBL. Considering all the evidence, it seems that self- and peer assessment has a valid and reliable place in evaluating attributes in PBL. In their review of peer assessment in engineering group work studies, Triantafyllou & Timcenko (2014) claims that 'peer assessment provided to be a valid process that resulted in substantial and meaningful feedback to students'. However, the extent of which peer assessment is valid and reliable can be influenced by its design, group formation, individual student experience in the use of peer assessment, and the students' personal attributes (Zhang et al., 2008; Thompson, 2001; Ohland et al., 2005). Initial observations by Van Gennip et al. (2009) suggest there is a possible link between what the authors are calling "student variables" and the extent of how reliable peer assessment is. The term student variables have been used as a collective to describe the many inter and intra personal characteristics, described in the literature as; psychological safety, value diversity, interdependence, and trust (Van Gennip et al. 2009) friendship bias, popularity, jealousy, or revenge (Ohland et al., 2005).

To date the majority of peer assessment studies have collected students self-reporting of learning in peer assessment practice (Strijbos and Sluijsmans, 2010). As Thompson observes: 'self-evaluations should not be used as a criterion for measuring truth or accuracy of team skills from self-directed inter-dependent teamwork' as the validity is low.

Taken together, these studies support the notion that students must be given adequate instruction of the process and multiple opportunities to give and receive constructive feedback. The nature of this feedback and instruction must enable the student to make sense and connection to the assessment process in the context of the total assessment experience and its educational outcomes.

5.9 Conclusion

The studies that adopted peer assessment to assess the attainment of learning objectives, employability and graduate attributes show that training and practice is required along with formative feedback (Strijbos and Sluijsmans, 2010). Little has been done to investigate the impact of student variables on the validity and reliability of peer assessment in engineering PBL when assessing the attainment of graduate attributes. There is still uncertainty, however, whether student variables would have an impact on the reliability of Peer Assessment. This research has thrown up many questions relating to the possible impact that student variables, team formation, and student training have on the validity and reliability of peer assessment in assessing graduate attributes in PBL. Further study with more focus on student variables, team formation and formative feedback is therefore suggested.

An important characteristic of group work is the ability of team members to evaluate each other's performance, but it can also serve the formal evaluation of learning outcomes and associated knowledge and skills developed.

Appendix A

Table 5-2 Overview of studies on peer assessment

No.	Title	Author	Date	N	Participants/study settings	Discipline	Subject of assessment	Relevant findings
*1	Peer Assessment for learning from a social perspective	Van Gennip et al	2009	N/A	Literature review	Multi	Learning outcomes, Formative assessment	See in paper literature review
2	Reliability and validity of student peer assessment in medical education: A systematic review	Speyer eta al	2011	N/A	Literature review/Peer assessment	Medical	Evaluating student learning	Need for well define criteria and psychometry characteristics to ensure reliability and Validity
3	Self & Peer assessment – does it make a difference to student group work	Elliot & Higgins	2005	17	Health Science/Post-graduate program	Medical	Group work	Peer assessment has an impact on student motivation to participate if their perceptions of fairness of the assessment system are met.
4	Methods to improve the validity and sensitivity of a self/peer assessment instrument	Duzer & Martin	2000	142	Pilot study	Engineering Design	Group work	A process employing both quantitative and qualitative methods was developed to improve the validity and sensitivity of self/peer ratings in assessing teamwork skills. Preliminary results indicate a dramatic improvement in the sensitivity of scales in measuring differences between student skill levels. The data also indicate that the process improves the validity of the ratings in measuring what the developers intended.
5	Peer assessment of competence	Norcini	2003	N/A	Review	Medical	Competencies	Given the broad range of ways peer evaluators can be used and the sizeable number of competencies they can be asked to judge, generalisations are difficult to derive and this form of assessment can be good or bad depending on how it is carried out. Factors influencing the quality of those assessments are reliability, relationships, stakes and equivalence.
*6	Peer assessment in problem based learning	Sluijsmanns Moerkerke, van Merrienboer and Docy	2001	27	PBL	educational sciences	Reliability of PA in PBL	See in paper review

	Title	Author	Date	N	Participants/study settings	Discipline	Subject of assessment	Relevant findings
8	Self and Peer Assessment: A necessary ingredient in developing and tracking students graduate attributes	Willey & Gardner	2009	255	Assessment instrument developing GA's	Engineering	Graduate attributes	Showed self and Peer assessment helped students develop GA's
9	Influences on assessment of graduate attributes in higher education	Hughes & Barrie	2010	N/A	Assessment	General	Graduate attributes	Without structured reflective process self and peer assessment has limited use in assessing GA's unless the issue of institutional and student range of diverse & interrelated factors are addressed in assessment
10	Peer assessment in imparting graduate attributes	Gomes et al	2008	Unknown	2nd & 3rd year students/case study PBL	Engineering	Graduate attribute	Student perception of using PA to impart GA's has merit
11	Student behaviour in peer assessment: a multi-criteria clustering approach	Krassadaki	2013	57	Engineering education	Engineering	Student attributes	A diagnostic procedure, which can be applied at the beginning of a course, in order to infer the most prevailing attitude among students indicate that students exhibit different PA policies
12	Peer Assessment in Problem Based Learning: A Qualitative Study	Painczak, Young & Groves	2006	165	1st Yr Medical	Medical	Attitudes and perceptions of peer assessment	Concerns were reported as to the negative impact PA has on cooperative, non-judgemental atmosphere of PBL without well-defined criteria with feedback
13	Sex does not matter: gender bias and gender differences in peer assessment of contributions to group work	Tucker	2013	1500	1st, 2nd and 3rd year students/ Teamwork	Business-law and environmental	Gender bias student interdependence	Little evidence was concluded as to gender bias in PA. Although multiple holistic rating in PA at regular intervals is effective.
*14	Assessing the reliability of self- and peer rating in student group work	Zhang, Johnston and Kilic	2008	134	Education and psychology	Teacher education	Evaluate reliability in terms of consistency	See in paper review
15	Peer Assessment in Problem Based Learning: Students Views	Llew, Alwis & Schmidt	2008	897	1st Yr polytechnic students/PBL	Not defined	Assessing peer work	Students reported that they did not let Interpersonal relationships did not influence their judgement in PA
16	Engaging with Graduate attributes through encouraging accurate student self-assessment	Lawson et al	2012	239	2nd yr undergrad students	Economics	Graduate attributes	Showed that for students to be able to understand criteria and standards for assessing, and so are able to make valid judgements on their work
*17	Relative Validity of Peer and Self-Evaluation in Self- Directed interdependent work Teams	Thompson, R.S.	2001	49	Final Year Capstone design course	Engineering	Validity of Self and peer assessment	See in paper review
*18	Effects of Behavioural Anchors on Peer Evaluation Reliability	Ohland, M., Layton, R., Loughry,M., Yuhasz, A.	2005	17 Teams	Junior level Undergraduate/Teamwork	Engineering	Effects of behavioural anchors	See in paper literature review

	Title	Author	Date	N	Participants/study settings	Discipline	Subject of assessment	Relevant findings
19	Developing employability skills: peer assessment in higher education	Cassidy	2006		Undergraduates	Medical	Employability skills	The study found that students expressed a positive attitude towards peer assessment but had concerns relating to their capability to assess peers and to the responsibility associated with assessing peers.
20	Students perceptions of fairness in peer assessment: evidence from a problem-based learning course	Carvalho	2012	120	Final year undergraduate	Management	Fairness perceptions in PBL	Negative relationship between fairness and interpersonal differences and team conflict
21	Peer assessment in Engineering group projects: a literature survey	Triantafyllou & Timcenko	2011	N/A	Literature review	Engineering	Group project work	Reported PA encouraged students to participate, minimised confusion of outcomes, was valid, and resulted in ownership of the process. Only if adequate guidance with specific criteria was provided.
22	Student perspectives on formative peer assessment: an attempt to deepen learning	Vickerman P.	2009	90	Undergraduates	Sports	Learning	The study found that on the whole formative peer assessment was a positive experience in enhancing students learning and development. However, consideration needs to be taken to address individual learning styles, as a limited number of students found the process to be less useful.
23	Explicitness of criteria in peer assessment processes for first-year engineering students	Van Hattum-Janssen N. & Lourenco J.M.	2011	152	First year engineering	Civil Engineering	Criteria reference	A negotiated criteria over 3 peer assessment opportunities were undertaken it was found a negotiated criteria enhance their motivation and deepen their learning while enabling students to provide formative justification of the grade
24	Authentic assessment strategies in problem-based learning	Tai G.X & Yuen M.C.	2007	53	Not defined	Multimedia	Assessment of PBL	Process assessment which contains of Self Reflection, Peer's Evaluation and Task Completion Reports allowed the students in identifying one's own progress and deficiencies.
25	How does student peer review influence perceptions, engagement and academic outcomes? A case study	Mulder et al	2014	60	3rd year undergraduates	Not defined	students' perceptions of the peer assessment	The study confirmed that participation in peer review can lead to important improvements in performance and learning outcomes.

	Title	Author	Date	N	Participants/study settings	Discipline	Subject of assessment	Relevant findings
26	New assessment forms in problem-based learning: The value added of the students' perspective.	Segers M. Dochy F.	2001	79	Undergraduates at two universities/	Business & Economics Education	PBL	Peer assessment was introduced for students to report on collaborative work during the tutorial meeting, and during the study period that follows these weekly meetings. Students perceive a gap between their working in the tutorial groups and the assessment. The results offer a valuable input for teachers to formulate concrete recommendations for optimising their educational and assessment practices.
27	Understanding the impact of assessment on students in problem-based learning	Savin-Baden	2004	N/A	3rd Year Bsc and BEng	Engineering	PBL	The article argued that many forms of assessment still largely undermine collaborative learning and team process in PBL
28	Peer Assessment in Higher Education: The Roadmap for Developing Employability Skills in Potential Job seekers	Paul, Chrispen and Alexander	2013	N/A	Undergraduate	Education	Employability Skills	Evaluation of the use of peer assessment to assess employability skills through student's perspective. It was found that there is a perceived positive attitude when engaged in peer assessment
29	Peer Assessment	Topping	2009	N/A	review		Approaches to Peer assessment	The article describes effective approaches to peer assessment and encourages teachers to incorporate it into their practice.
30	Self and peer assessment in school and university. Reliability, validity and utility	Topping	2003					
31	Self and Peer assessment as an assessment tool In problem - Based learning	Tan & Kait	2005	131	3rd year PBL course	Marketing	PBL	The research shows that there is a need to re-evaluate the use of self- and peer-assessment in the Problem-based Learning context results of the investigation described in this paper demonstrate that the reliability of self- and peer-assessment in problem-based contexts cannot be assumed. It was found that the involvement of students in the formulation of assessment criteria is a way of assuring PA as a valid assessment tool in Problem-based Learning.

	Title	Author	Date	N	Participants/study settings	Discipline	Subject of assessment	Relevant findings
32	Self and Peer Assessment for group work in large classes	Thompson & McGregor	2005	90 - 200	Undergraduate	Design & Business	Professional Skills/online tool	The use of the tool showed a positive on formative feedback in group based work. Student feedback about the self and peer assessment process showed evidence of deeper approaches to their reflections about the value of group work and the attributes they were developing through it
33	Peer-assessment in Group Projects: Is It Worth It?	Kennedy	2005	Not given	Undergraduate/Case study	Computing	Group projects/course objectives	The study raised a number of issues relating to the use of peer assessment as a mechanism for distributing group marks to individual team members in group projects. Peer assessment actually detracts from the attainment of course objectives
*34	Effective peer assessment processes: Research findings and future directions.	Van Zundert, M.,Sluijsmans, D., & Van Merriënboer, J.	2010	N/A	Literature review	Multiple	Effective PA processes	See in paper literature review

* Summary reviewed papers in this article

CHAPTER 6 Validity of Peer Assessment in Problem Based Learning

This research was originally published as;

"INTERPERSONAL VARIABLES AND THEIR IMPACT ON THE PERCEIVED VALIDITY OF PEER ASSESSMENT IN ENGINEERING PBL"

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CHAPTER 7 Formative & Reflective Feedback Model: impact on peer assessment of graduate attributes in PBL.

This research was originally published as;

"FORMATIVE PEER ASSESSMENT MODEL IN MARITIME ENGINEERING UNDERGRADUATE PROBLEM BASED LEARNING"

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Abstract

This paper presents the results of an experiment that introduced team contracts and reflective intervention on peer assessment in a final year design project. We look at two conditions: (1)Students (N=36) undertook milestone group peer assessment of pre-determined graduate attributes criteria set in their team contract, at each milestone submission individual team member provides a reflective narrative and staff mentor provided feedback to team members. The nature of the academic staff mentor feedback was the resultant peer assessment compared against the team contract criteria and the team members' reflective narrative. This provided an individual student insight into the results of the feedback. Students were then asked to convene a team meeting to discuss the results and re-address any perceived issues against the team contract criteria; (2) Students (N=12) undertook the same peer assessment and team contract criteria but were not offered mentoring intervention on their formative peer assessment results. Semi structured interviews and open-ended questions conducted with the students before and after the mentor feedback sessions in condition (1) and after the peer assessment feedback in condition (2). Results indicated the model introduced in condition (1) showed students experienced a closer bond and feeling of trust and psychological safety between team members, summative assessment results showed a closer and repeated correlation to actual mentor observed student interaction and attainment of graduate attributes assessed in the project. Students in condition (2) showed no marked improvement in their engagement with peer assessment and appeared to act independently within the team.

7.1 Introduction

The significant increase in the use of teams and problem-based learning (PBL) in higher education has seen substantial work on factors that influence team performance (e.g. Mathieu, Maynard, Rapp, & Gilson, 2008; Tan & Keat, 2005; van Gennip, 2012). Within this context, the design and implementation of assessments, including peer assessments, constitute important aspects in the current developments of PBL. The implementation of peer assessment has largely focussed on the production of artefacts and professional/student assessment against student contribution to group work. Davies (2002) stated that peer assessment enhances student learning, while Doch & McDonelll (1997) argued that peer assessment allowed students to develop skills in areas of communication, self-evaluation, observation and self-criticism. Van Gennip et al. (2009) makes the analogy that peer assessment is fundamentally a social process, 'whose core activity is feedback given to and received from others', making peer assessment a process of interpersonal interaction. The reported benefits of self and peer assessment in the PBL environment is that it can be used to assess students' problem solving, teamwork, and self-directed learning skills (Wee & Kek, 2002). The authors have previously presented work (Symes, Ranmuthugala, and Carew, 2014) showing that there are interpersonal variables (referred to as student variables) that come into play during the peer assessment process, that have an impact on the reliability and validity of the peer assessment process. The authors made the case that the impact of student variables needs to be taken into account during the design and implementation of the peer assessment process.

Despite significant efforts towards student centred education, many are yet reluctant to give students the role of designer and/or assessor of their education (Sluijsmans, Moerkerke, van Merrienboer, and Dochy, 2001). Many studies in peer assessment focus on the reliability between student and professionals rather than those of other peers or the same peers over a period of time. Recent evidence suggests that there are potential drawbacks with peer assessment, questioning student's ability to reliably assess themselves and their peers (Dochy et al. 1999; Lew, Alwis, Schmidt. 2010).

The development of a reliable model in the implementation of peer assessment is imperative to ensure a valid and reliable assessment of the learning experience. Following on from the findings presented by the authors in Symes et al. (2014), a model was proposed that allowed students to set, against pre-determined GA criteria, their own measurable outcomes and actions in the form of a team contract that as a team they agree to enact and adhere to during group work. There is, however, a paucity of validated, criterion-based peer and self-assessment instruments that report the assessment of the attainment of GA's. For students to engage and reflect on the learning as well as make sense of feedback from the peer assessment process, two main factors must be in place, firstly extensive student training in peer assessment, and secondly assessment feedback must be on time and focused. This paper presents the PBL approach used in this study by engineering undergraduate students including a brief summary of pre-study assessment method (PBL-Assessment model) used, and the iterative approach in the development and accessing of a formative peer assessment model (Formative PBL-Assessment model). Both models included a team contract, with the Formative PBL-assessment model introducing peer and mentor feedback. The formative PBL-Assessment model proposed in this research attempts to encompass PBL, mitigate the impacts of student variables on the peer assessment instrument and have students take ownership of their learning in the attainment of GA's through a reflective peer assessment feedback loop. Selective observation was adopted, using each team's contract as the basis for assessing interaction and adoption of the model. Results showed students engaged in adopting the team contract and peer assessment process to some extent, with the team contract influencing the interaction between the team members. Observations also showed that team members recognised the impact of the student variables and provided constructive input into how measures can be put in place to minimise their impact. This interaction stopped after two milestone submissions, and team members chose not to maintain the ongoing adoption of formative feedback into their contract or changing their approach to mitigating any student variable issues with the peer assessment process. The team members continued to operate as individuals within a team environment, contributing only to their agreed input to the milestones.

The paper concludes by presenting unanswered questions about the formative PBL-Assessment model, lessons learned, future research and the impact on peer assessment, in particular, its reliability for assessing engineering PBL programs.

7.2 Problem-based Learning Environment

The final year 'Design Project' unit of the Bachelor of Engineering program conducted at the Australian Maritime College is a multi-disciplinary unit that spans across two semesters (26 weeks) providing students exposure to the actual engineering design process within a realistic industrial environment. The unit uses a PBL approach as outlined in Thomas, Harte & Pointing (2013) where an industry driven project that requires interaction by the student team with external clients and relevant industry sectors. The unit is a design workshop environment with weekly six-hour sessions where the lecturer assumes a consultation or facilitator role. These sessions focus on tracking individual student and team progress, while providing guidance and advice as required, without interfering with the focus and working of the individual teams.

The integrated design project is conducted through a team-based approach, where maritime industry aligned and supported design projects are allocated to individual student teams. This allows the development and assessment of student GA's such as teamwork, leadership, communication, ethics, professional conduct and negotiation skills in addition to technical knowledge and skills including systems engineering proficiency.

Allocation of the team members was carried out using a combination of student choice on the project focus (for example the type of maritime platform being designed) team roles and personality analysis using methods such as Belbin Team roles (Belbin,1993), and Myers-Briggs personality type (Myers & McCaulley, 1985). Using this information the unit coordinator constructs the appropriate groups. The early stages of the project allow students to focus on team development, such as allocation and acceptance of team member responsibilities and the development of the team contract. Each group is required to draft a Code of Conduct or 'Team contract', which outlines the groups agreed outcomes against GA criteria and expected project milestones.

7.2.1 The team contract and student variables

A team contract or code of conduct is generated at the commencement of the project to establish procedures and roles of the team and its members. This aids the development of team working relationship helps identify the goals, and criteria the team members collectively wish to achieve, the desired level of group participation and the expected individual accountability and roles of responsibility they feel comfortable with. The process of generating a team contract sets out to concentrate the team's collaborative efforts by facilitating communication and negotiation, immediately focusing the team members on a definite project task. In a team environment, individuals are usually effectively motivated to maximise their own performance and minimise their effort in contributing to the outcome of the team (Slavin, 1989). In the context of this study, the team contract not only sets out the project and individual deliverables, it established an interpersonal dialogue which allows interpersonal synergy between team members to reduce the overall variance of their joint activity, making them more similar and regular in their approach to peer assessment. Such behaviour matching is considered to assist the team to achieve common grounds, improved rapport, and enhance collaborative performance among the team members (Fusaroli & Tylen, 2012; Marsh, Richardson, & Schmidt, 2009). It is hypothesised that this approach can minimise the effects of student interpersonal variables on the peer assessment process and feed into the PBL project, resulting in a reliable and valid learning and assessment activity (Symes et al. 2014).

The team contract is broken into five specific topic areas with each topic further subdivided into sub topics as shown in Table 7-1. Each topic is aligned to the relevant GA's of the undergraduate program, and student variables such as Psychological Safety, Value Diversity, Interdependence, and Trust.

Table 7-1 Team Contract Topics

Topic	Sub Topic	Descriptor	Graduate Attribute	Alignment to student variables
Team Relationships	• Inclusive climate • Member Commitment • Conflict Resolution	The team must define consensus expectations about productive with-in team relationships. What constitutes the relationships needed for productive, enjoyable teamwork? How are these relationships developed and maintained?	• Working in Teams • Effective communication • Behave as a professional	Trust, Psychological Safety, Interdependence
Joint Achievements	• Goal Establishment • Planning and Management • Joint Work Products	The team must define consensus expectations about team goals and joint achievements. How will goals be used to drive overall team performance?	• Behave as a professional • Negotiate the business environment	Value Diversity, Trust
Member Contributions	• Work Allocation • Performance quality • Member Growth	The team must define consensus expectations about individual team member contributions. How will work be allocated, performance standards established, and performance reviewed to ensure member productivity?	• Working in Teams • Effective communication • Behave as a professional	Psychological safety, Value Diversity
Team Information	• Internal Communication • Stakeholder	The team must define consensus expectations about handling project information. How will communication within and outside the team	• Effective communication • Negotiate the business	Psychological safety, Interdependence, Trust

	Communication • Knowledge Assets. • Decision making Policy	are managed? How will ideas and decisions be documented?	environment	
Roles and Responsibilities.		As a team, they base their roles on each individual Belbin team role/Myer-Briggs personality results or as identified for each member the leadership or backup responsibilities for which the team member is accountable to the team.	• Behave as a professional • Working in teams	Value Diversity, Trust

The students are required to discuss and come to a consensus on each topic and consider its impact on the outcome of the project deliverables while using peer assessment to measure how the team members engaged in fulfilling the agreed contract.

7.2.2 Assessment

Assessing students' acquisition of GA's and learning outcomes in the PBL environment has been well documented in the literature (Bielefeldt, Paterson & Swan, 2009; van Barneveld & Strobel, 2009). A varied assessment strategy is utilised in this design project to ensure that students are able to demonstrate that the required learning outcomes and graduate attributes are achieved. The concept of PBL concludes where possible, learning and assessment occur simultaneously. Student participation and attainment of GAs in the design project unit is assessed using five milestone artefact and peer assessment submissions. In this unit, one such example of a milestone artefact would be the preliminary design brief report, while peer assessment outcomes focused on skills such as timeliness, communication, contribution and professionalism. A PBL-Assessment model (Model 1) was developed for delivery into a final year PBL engineering design course, in an endeavour to increase perceived validity and reliability issues, such as contribution both physical and intellectual, of project deliverables and the use of peer assessment in assessing the attainment of program GAs.

WebPA (WebPa, n.d.) is an online tool that facilitates the collection self and peer assessment and is used within the PBL Assessment model to allow students to confidentially assess their peers. As WebPa is a criteria-based tool it allows academics to choose or create specifically targeted criteria including the development of graduate attributes and or discipline-specific attributes to be assessed? The self and peer assessment criteria in this subject required a series of questions to be answered that aligned to their team contract topics (see Table 7-1 above), graduate attributes and project specific criteria. Students are required to rate themselves and their peers using a 1 – 5 Likert scale and provide individualised feedback and justification for their rating. Figure 7-1 below shows a screen dump of example questions linked to the team contract

Rate each team members contribution to developing the team contract
The criterion and articulation of ideas in the development of the team contract
Scoring range: 1-5
Score 1 : Contributed no useful original ideas
Score 3 : Made an average contribution in this respect
Score 5 : Contributed useful and original ideas

Respect
Does the team member listen and engage in constructive discussion. Give constructive criticism. Behave politely and courteously in all discussion.
Scoring range: 1-5
Score 1 : Never
Score 3 : Sometimes
Score 5 : Always

Professionalsim
Act ethically and in a professional manner when dealing with team members.
Scoring range: 1-5
Score 1 : Rarely or at a low level
Score 3 : Usually and at an average level
Score 5 : Always and at an exemplary level of professionalism

Participation
Team member engagement within the development stage of the contract in terms of meetings.
Scoring range: 1-5
Score 1 : Team member did not participate, wasted time, or worked on unrelated material
Score 3 : Team member made some attempt to participate
Score 5 : Team member participated fully and was always on task

Time Management
Ability of team members to prioritise time/tasks in relation to the development of the contract
Scoring range: 1-5
Score 1 : Team member did not complete most tasks on time
Score 3 : Team member completed tasks but had to be pushed
Score 5 : Team member always completed the assigned tasks on time

Figure 7-1 WebPa Question bank example

Three design milestone checkpoints are used through the project, which are used to ensure the teams adhere to the project time line. The milestones are used to assess both the technical aspects of the project and together with peer assessment, the progress made by the team and the individual team members. The unit lectures provide feedback on the technical progress of the project using comprehensive marking rubrics allowing students to understand what is required within each assessment and how that item relates to the learning outcomes of the unit. The milestone checkpoints are not formally assessed, but penalties are enforced for noncompliance to submission requirements. The final project artefact consists of a final design report, oral examination and a team presentation. The final artefact is formally assessed and uses a combination of, criterion referenced assessment (CRA) process to determine the overall team mark, and student self and peer assessment grade to determine the individual student final grade.

7.2.2.1 PBL-Assessment model 1

The PBL-Assessment model introduced a team contract along with peer assessment in an attempt to influence team members' contributions and engagement in a PBL design project while mitigating the perceived effects of student variables on the project artefact and peer assessment of graduate outcomes.

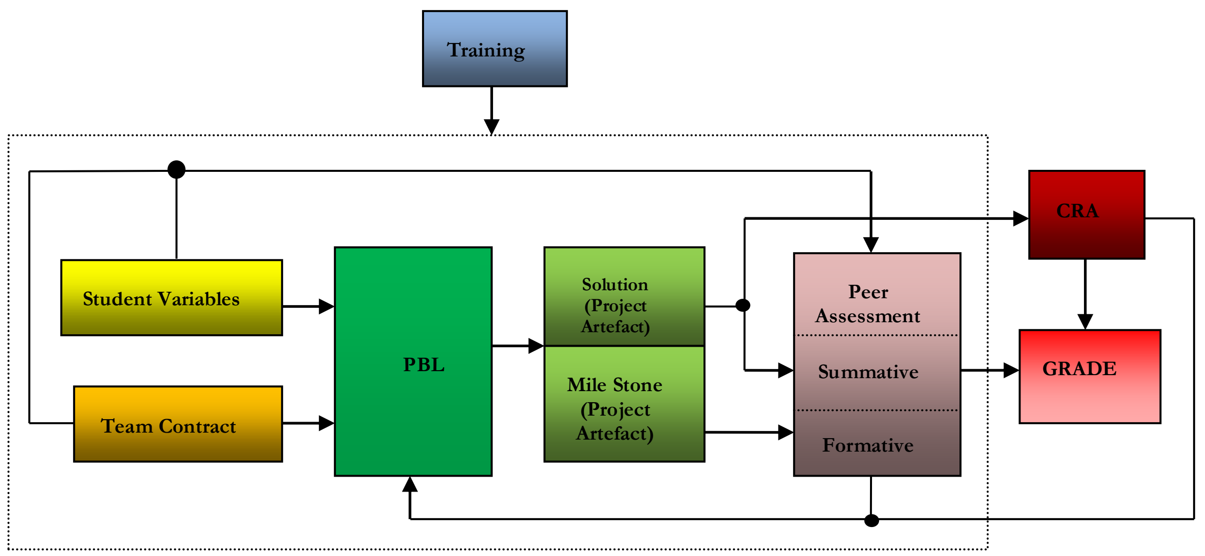

Figure 7-2 PBL-Assessment model 1

The model consisted of a number of sub-topic and influencers as described below:

- **Training:** Training encompasses the whole PBL Assessment model. Students are instructed on how the model works. They are helped in learning how to make and justify their judgements using evidence that is directly relevant to particular criteria, be it the team contract, the influence of student variables and/or the peer assessment criteria.
- **Student Variables:** These influencers are a set of variables (shown in Table 1) affect how students engage and learn within PBL and the associated peer assessment process.
- **Team Contract:** The team contract contains a number of topics outlined in Table 1. The purpose of the contract is to enable the students to take ownership and be committed to the topics at an agreed level of answerability. A guide and template was utilised to provide students training on: formulating a team contract, how to peer assess, and how student variables might impact on the outcomes. This allowed all students within the team to engage and take ownership of its design.
- **PBL:** is a teaching method defined by Larmer, Mergendoller, and Boss (2015) as an learning experience in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and problem or challenge. PBL in this study is the student experience as described in section 7.2.
- **Milestone Artefact:** The milestone artefacts are a series of design checkpoints used to ensure the teams adhere to the time constraints of the project. These check points are used to provide formative self- and peer assessment and technical progress feedback.

- **Solution Artefact:** The solution artefact is in the form of a final design report, providing summative feedback through peer assessment and criterion referenced assessment (CRA).

- **Peer Assessment:** For each milestone submission a self and peer assessment is undertaken and student feedback on progress against the team contract is evaluated. The solution artefact includes a self and peer assessment that informs the CRA to determine the individual students' final grade.

- **CRA:** Criterion referenced assessment is used to provide a summative assessment on the technical aspects of the solution artefact, and informs the final grade.

- **Grade:** The grade is the final student summative grade and is determined by the combination of peer assessment and CRA.

The two assessment pieces were structured at the stages of milestone submission requirements within the project, and included a combination of formative/summative self and peer assessment and CRA. With each pre milestone submission, the students are assessed on the deliverable of the milestone using CRA to apply a grade and a formative peer assessment process is utilised, using self and peer assessment, to provide feedback on the individual team members' engagement in the team contract and their contribution to the milestone deliverable.

Gibbs and Simpson (2004) state "Formative assessment provides the best learning support because it allows the student frequent opportunities to perform and receive suggestions for improvement". Regular formative assessment was provided through the peer assessment activity, which allowed the students to inform the PBL process and minimise the impact of student variables on how they performed in the learning environment and approached peer assessment.

Regular formative assessment was provided through student comments made in the peer assessment activity. The feedback took the form of a numerical percentage against each of the contract topics, rated against each student and comments justifying the rating of their peers. This allowed the students to inform the PBL process through comparison against expected and actual team contract topic expectations. It was hypothesised that the impact of student variables would be minimised and their engagement with the learning environment and the peer assessment process would provide a more reliable outcome.

7.3 The Problem

Symes et al. (2015), claims that the PBL-assessment model 1 did not increase the reliability of peer assessment, by minimising the impact of student variables. The students reportedly still used the peer assessment process to influence the grading outcome of themselves and their peers. A new approach, the "Formative PBL- Assessment model" was introduced, where an additional self-reflection, feedback and mentoring cycle were introduced into the model. It is hypothesised that the introduction of a self-reflection formative approach to feedback with additional mentor support would mitigate the influence of student variables on the outcome of self- and peer assessment. The first iteration of the Formative PBL-Assessment model took place in a final year maritime engineering design unit at the Australian Maritime College.

7.3.1 Formative PBL-Assessment model

Schön (1983) defined reflective practice as two capabilities, reflecting in action whilst doing something and reflecting on action (after an action has been done). Kolb (1984) produced a cyclical model for learning where reflective practice forms an integral part of an individual's learning through an experience. In this context, combining these two theories the PBL-Assessment model was modified to include a reflective mentor directed feedback mechanism, as shown in Figure 7-3, and was identified as the "Formative PBL-Assessment model", one that is:

- valid and fair by managing within-group conflicts, discouraging 'free-riding' and reducing assessment-related complaints;
- universally applicable, irrespective of the group size or field of study;
- readily comprehensible by tutors and students alike, without offering individuals opportunities to exploit the model for their own benefit;
- demonstrates higher order thinking when undertaking peer assessment;
- enables students to identify the impact of student variables on peer assessment;
- encourages reflective assessment of the PBL and peer assessment experience; and
- easy to implement in practice.

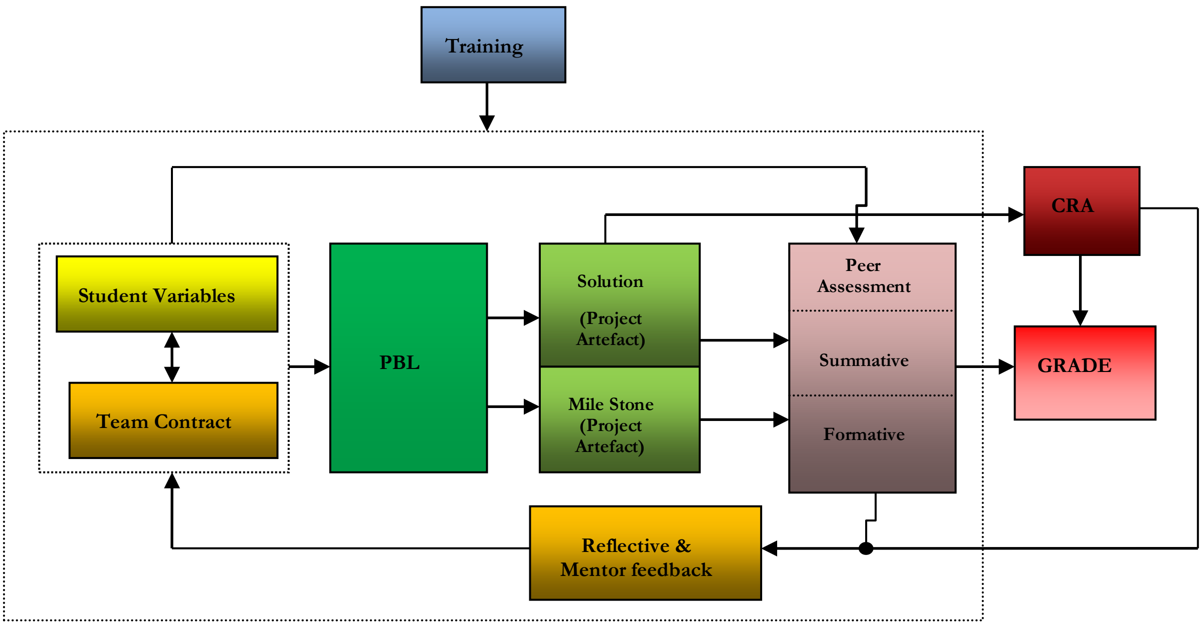

Figure 7-3 Model 2 - Formative PBL-Assessment model

The Formative PBL-Assessment model resulted in a more holistic approach to identifying the influencers of the team contract and student variables on assessment and deliverables. The peer assessment process required the students to add comments to justify their assessment of self and peers. The reflective and mentor feedback mechanism introduced not only addressed the team contract and student variables but also was one further means of informing team performance and learning in the PBL environment.

The reflective and mentor feedback addition to the model introduced three activities engaged the students in receiving and addressing feedback after self- and peer assessment. The primary purpose of the introduction of the reflective feedback process was to enable the student to provide instructional opportunities that relate specifically to the experience of the student. This relationship encourages the student to develop purposeful personal and professional understanding (Castelli, 2011). The overall structure of the reflective mentor feedback was adapted from Castelli and illustrated in Figure 7-4. This model adopted five major elements:

- openness
- purpose
- meaning
- challenging beliefs
- ongoing dialogue and feedback

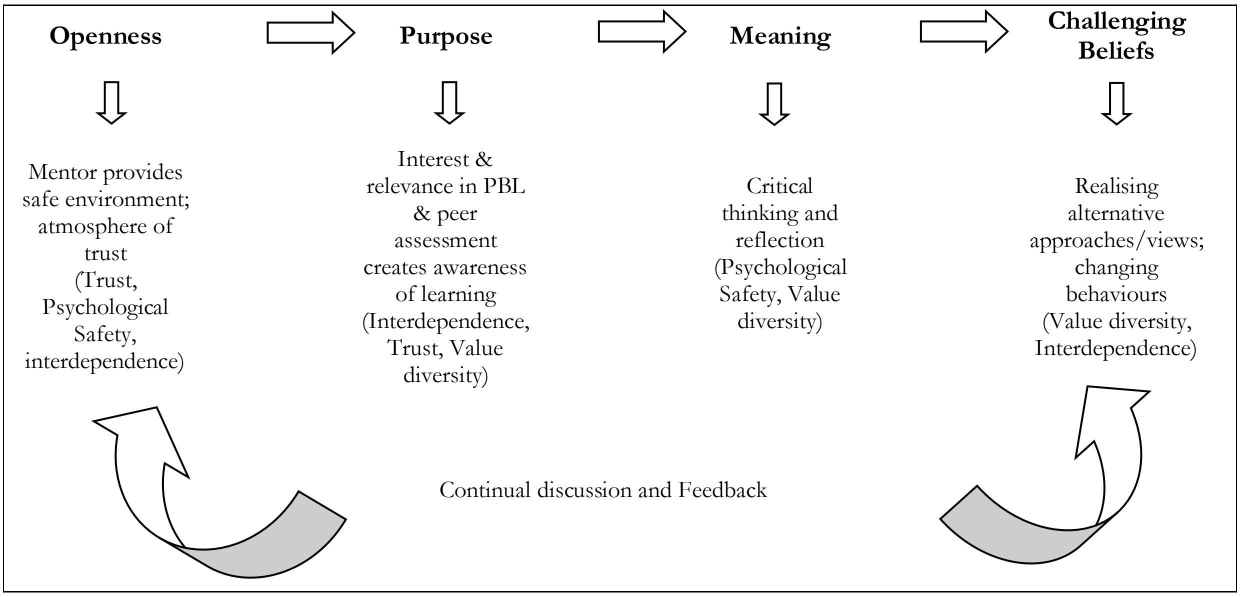

Figure 7-4 An Integrated Model for Incorporating Reflective Learning (Adapted from Castelli, 2011)

The mentor's role was to create openness while providing a safe environment and an atmosphere of trust where students will be more at ease at engaging and share their experience.

Each element directly related to aspects of student variables, shown in brackets in Figure 7-4 that were seen as an issue with providing a reliable assessment outcome. Each element is experienced by the student through three steps described in the following sections.

7.3.1.1 Self-reflection

The feedback and criteria result from the peer assessment process was de-identified and provided to the students. The intention of removing the identifiers was to allow the student to analyse the information without bias. On receipt of the peer assessment feedback, the students were encouraged to self-reflect on the outcomes. Finding meaning and significance in the assessment feedback process, which allows the student to question conflicting thoughts and assumptions based on their understanding of the PBL experience.

Out of the self-reflection, the student must bring to the team meeting points of concern/conflicts, evidence of positive outcomes from the assessment and recommended changes or amendments to the team contract. This reporting develops a sense of meaning for the student, where the student may find that their understanding may not be accurate and therefore will begin to consider alternative approaches and tangible ways to change their behaviour (Castelli, 2011). When the student is forced to explain their reasoning, it provides an opportunity for them to see gaps in their understanding and logic (Chi et al. 1994)

7.3.1.2 Team meeting

Team meetings agenda allow the students to discuss their feedback and analysis. Which supports the development of the team contract topics such as *team relationship*, *member contributions*, *team information*, *joint achievements*, and *team information* by enhancing the benefits of analysis, providing feedback and receiving feedback. The mentors provided a non-bias support and advisor to the team. The team meeting allowed the students to safely explain their ideas verbally, while also openly discussing problems more broadly and how it links to their and the team's performance and its possible impact on the team contract and team interdependence.

7.3.1.3 Team revision

The team used the team meeting to close the feedback cycle. Hughes, Ginnett and Curphy, (2009) developed the Action-Observation-Reflection (A-O-R) model shows that students development of their understanding of PBL, and how PBL links to GA and the peer assessment process is enhanced when the experience involves three different processes: action, observation, and reflection. Hughes et al., state:

> *If a person acts but does not observe the consequences of her actions or reflect on their significance and meaning, then it makes little sense to say she has learned from an experience. Growth occurs as a result from repeated movements through all three phases rather than merely in terms of some objective dimension like time.* (p.54)

The team utilised the A-O-R model to develop strategies and identify gaps in their team contract and their approach to the PBL process. Such strategies may include, increasing effort, motivation and engagement or revisiting the team contract and pursuing new approaches to how they interpret the contract topics. As a team and individually they negotiate and adjust their performance, and readjust their understanding of the goals of the contract and the impact of student variables that may have played a part in the process.

7.4 Method

The present study using the Formative PBL-Assessment model was used to analyse the model's effectiveness as well to obtain feedback about student interaction, participation, and the model's validity and reliability in the self and peer assessment process. The study was undertaken with a group of students drawn from a final year design project user population and data was gathered through observations and interviews.

The Formative PBL-Assessment model was trailed on 36 students in six teams. While 12 students in two teams continued to use the previous PBL assessment model. All teams undertook the same team contract criteria self and peer assessment at each design milestone.

The teams were required to convene a team meeting, on receipt of the peer assessment outcome, to discuss and reflect the results of the peer feedback and re-address any perceived issues against the team contract criteria. Individual team members were also to self- reflect on the team and project outcomes

A qualitative approach using semi-structured interviews were conducted to generate an understanding of the range of opinions and experiences of students when they were exposed to the Formative PBL-Assessment model against those that were exposed to the original PBL-Assessment model. The first stage of this study explored the use of the PBL-Assessment model, while the second stage built on data obtained from the student experience by developing a Formative PBL-Assessment formative model. Our hypothesis was that students that participated in the Formative PBL-Assessment model were influenced in their approach to peer assessment by engaging in individual, team reflective and mentor feedback. An interpretation of the theoretical framework based on the work of Biggs (1979) and Ramsden (1992) describing the interactive relationship among student variables, assessment context and the task and learning outcomes were used.

7.4.1 Study population and condition

The study participants were maritime engineering undergraduate students who were in a two-semester long final year design project. This convenience sampling was undertaken to gain students experience and perceptions of the Formative PBL-Assessment model, with the data cross-referenced with the peer assessment submissions. The study included students (N=36) in 6 teams of 6 members (Group 1) who undertook milestone group peer assessment of pre-determined graduate attribute criteria set in their team contract. At each milestone submission, each individual team member provided a reflective narrative, while the staff mentor provided feedback on the outcomes of peer assessment to the team. The nature of the staff feedback was based on the resultant peer assessment against the team contract criteria, while the team members' reflective narrative provided an individual insight into the results of the feedback. Students were then asked to convene a team meeting to discuss the results and readdress any perceived issues against the team contract criteria. The study also included students (N=12) in 2 teams of 6 members (cohort 2) who continued with the PBL-Assessment model 1, they were not provided with a mentor, but were instructed to as a team discuss and take action on the results of their assessment. This action was in the form of addressing shortcomings in their team contract that may have influenced their assessment feedback and criteria ratings.

7.4.2 Data collection

Semi structured interviews and open-ended questions were employed with the students before and after the mentor feedback sessions. The study explored the students' experience of the feedback process, how they interacted in the development of the contract, engagement in team relationships, and impact of student variables. The first author, who was not involved in the academic experiences of the students participating in the study, thus removing bias, conducted the interviews.

7.5 Results

A theoretical insight presented illustrates how students with different perceptions of student variables are influenced by reflective interaction and how this interaction affects their engagement with peer assessment. The results were framed into three main themes:

- students personal perceptions of the PBL-Assessment model function;
- students engagement with the PBL assessment model; and
- students outcome in the adoption of change through reflective intervention.

In the following sections, these themes are presented with illustrative quotes from staff (S1 to S2), mentors (M1 to M2) and from the six student groups (G1to G6 in cohort 1 and G7, G8 in cohort 2).

7.5.1 Students personal perceptions of the PBL-Assessment model

7.5.1.1 Team contract development and implementation

The implementation of the team contract was deemed by the unit staff as being instrumental in allowing the teams to set priorities, define positions of responsibilities, and open up dialog between team members. It was perceived as a major factor in stimulating team members to accept responsibility, communicate individual expectations and establish a means of addressing the possible impact of the student variables on the project as a whole. The team contract can thus be considered a motivational strategy for engagement in the PBL-Assessment model, as described by a participating student,

> *"If you are going to be held accountable and have an opportunity to use the team contract as a motivator I think it is great"* (G2).

Student group 1, 2 and 4 (G1, G2 & G4) noted that the team contract provided an opportunity to break down any prior misconceptions and biases on team development and responsibilities, for example,

> *".. i reckon it was cool we got to really talk to each other. The mentor* (M2) *helped us to see how important it was to use the contract properly and it helped our team work closer"* (G1).

Unit staff likewise observed the team contract as a stimulus for student interaction and a motivator to develop a team approach to the PBL project, while helping teams learn to inquire, contribute, comment, share, respond, listen, and revise ideas.

> *"I did notice greater discussion during team meetings…whether that translates to a greater engagement with the model I am yet to see"* (S1).

> *"I saw change in some groups when using this; I think we may have something here"* (S2).

All student groups, however, saw the whole team contract process as just another academic hurdle introduced to slow their desire to just "get the project done". The data suggests this perception is in part a result of how students view team based projects.

"we don't like team work so much, I like working alone in my time…in the end each of us just did what we had to do" (G5).

"I could see the benefit in the end but it stills a lot of work over and above the project we had" (G1).

These views were a result of multiple personal and conceptual understanding of team based PBL, which includes students' perceptions of peer assessment.

7.5.1.2 Formative peer assessment and mentor/reflective feedback

Cohort 1 students were provided mentor feedback as well as the peer assessment grade and associated comments and asked to reflect on the outcomes and provide input via team meetings as to how they might readdress the team contract while identifying possible student variable influences. Cohort 2 students were only provided with the formative peer assessment but instructed to as a team to address how they might improve or change as a result of this feedback.

All groups, as with their view on team based PBL, saw peer assessment as a way to "get back" at team members who in their view, did not contribute and did not trust or felt disempowered by the process. This view was held in part because to date all students had been involved in summative only self and peer assessment processes.

"having to do peer assessment at each submission meant I would look at what didn't go well…I would let the lecturer know I wasn't happy with a team member"

"I know you could get your marks better than the others if you graded them lower and me more"

However, students in cohort 1 when questioned after the second round of feedback were feeling more confident in the process and saw the PBL–Assessment model as a way to communicate their concerns and understood the link between the impact of each other's student variables on the process as a whole.

"…it's a good way to get the team talking we could understand what we needed to change" (G1).

Students in cohort 2 did not have such a significant shift from their initial views on peer assessment; however, it was reported that the extent of the difference between team members grades were influenced by the fact they had to justify their rating of the team member.

Students' in group 1 (G1) considered assessment to be fair and stimulated constructive dialog in team meetings when they become aware of the connection between the outcomes of the team contract and the impact of student variables.

" … I never liked peer assessment I had no control over the outcome… or I used to think that but I get it now and when we can talk about and have our views listened to we end up working together" (G1)

The students in group 1 (G1) improved in their ability to diagnose team issues and as a team planned and implemented strategies to mitigate possible impact of student variables and lack of participation.

7.5.1.3 Students engagement with the PBL-Assessment model

Group 1 students were more enthusiastic with engaging in the PBL-Assessment model and reported being more comfortable over time in discussing their views on how the team and individuals were functioning against the team contract. This was a view reflected by the mentor and unit staff.

"it's down to training and each student feeling safe and confident to contribute, it could be maturing thing during the time of the project as well" (M).

All groups engaged with reflection against the formative feedback received. However, cohort 1 students through connection with the mentor were better able to make sense of the reflective process and act on the feedback. This engagement was evident in the reflective approach and detail used of the formative comments used in WebPa. A clear connection was being made between outcomes and student variable influences, which resulted in an approved ability of students to negotiate change either in their team contract or in the way they dealt with the impact of student variables. Cohort 1 students were more accommodating of negative feedback and perceiving it positively than were cohort 2 students.

"Once I understood how my actions and those of my team mates impacted how we approached peer assessment…. I actually think the negative feedback was good I thought about it more and make connection to what we did" (G3).

The data suggests that the engagement by cohort 2 students were generally more superficial and geared towards quick short-term results. Although there was evidence of reflection on the formative feedback, the comments within peer assessment were connected to influences of student variables. The feedback was treated as criticism and of no constructive value, resulting in little to no action to address perceived team issues.

"..most of us just gave the same comment…we didn't want to upset anyone what's the use in the end we just wanted to finish it" (G7).

".. some of the feedback we got we would just say yip and bin it" (G2)

The presence of broad, imprecise direction by team members on action against formative feedback resulted in variations as to how group 2 students engaged in peer assessment or acted upon the formative feedback process.

7.5.1.4 Student outcomes in the adoption of change through reflective intervention

All students in both groups preferred and appreciated the formative and reflective approach of the PBL-Assessment model, prior to the implementation of the final summative peer assessment. However, there was little change to the assessment results with cohort 2 from the formative feedback to the summative. Cohort 1 showed a definite improved team connection and understanding of the impact and relationship of having a dynamic team contract and the impact of student variables on their approach to the project and peer assessment.

By combining reflective practice allowing the student to identify the impact of student variables and with the guidance of mentors, the students were able to implement informed change to their approach to the team contract and peer assessment process with a better outcome of the project. Mentors noted a change in approach among the students from cohort 1 where over time they were more inclined to provide informed and constructive input into the team meetings, inferring they had learnt to trust each other and understanding the value of giving and receiving informed feedback.

".. again I see how the students really got into bringing their reflections back to the team meetings and genuine discussions and consensus on putting change in place was witnessed" (M2).

There was no significant long term change to the approach cohort 2 students took towards peer assessment. Although there was a better awareness of the connection between the impact of student variables and reflective practice, students still resorted to practices witnessed in the pre-trials using the PBL-Assessment model.

" we still see the same issues play out with the G7 & G8 teams on peer assessment and team work with the friendship being the dominant issues" (S1)

7.6 Discussion

The primary focus of assessments is to encourage, direct and reinforce learning. In addition, assessments should be capable of indicating achievement, maintaining standards and providing certification. Jaques (2000) highlight the importance of students given an opportunity and time to develop skills in self and peer assessment this skill development promotes self-awareness on more complex concepts.

This paper describes the experience with a formative PBL–Assessment model on two cohorts of maritime engineering undergraduate students participating in a final year design project using a PBL approach. Students that were exposed to the formative PBL-assessment model adopted a positive interdependence approach to team development and the project. The PBL-Assessment formative model implemented in this study shows that the adoption of a reflective/mentor feedback process improves engagement, improves and builds trust and students perception of being safe to assess and be assessed.

In modern engineering curricula and education, PBL and group work is accepted as a part of the overall assessment strategy. The challenge confronting the educator is to consider means of assessing not only the process and outcomes but also maintaining adequate validity and reliability in the assessment process. To maximise the educational impact of the PBL-Assessment formative model and to avoid the negative effects of students variables, a combination of reflective engagement in interpreting feedback under the guidance of a mentor is required, ensuring a valid and reliable outcome. Students and staff should be prepared prior to the implementation of the PBL-Assessment formative model through adequate orientation and development programs. In general, the students were very positive with regard to the overall concept, although they did raise concern about some aspects of the implementation. Their comments on specific components were noted and used to inform subsequent development of the PBL-Assessment model.

Overall, the findings from this study support the use of a Formative PBL-assessment model for PBL in the context of this study in maritime engineering education but has benefits to other fields of education that uses PBL. This study indicates that students found the use of the Formative PBL-assessment model an effective strategy in reducing the influence of student variables and increasing the reliability and validity of assessment in PBL group work.

7.7 Conclusion

Findings from this study indicate that the use of the formative PBL-assessment model does make a difference to students' perceptions of self and peer assessment within the PBL environment. The formative PBL-Assessment model develops student skills in negotiating the influences of student variables on the reliability and validity of self and peer assessment. It further develops skills in allocation and monitoring team member participation and accountability to the outcome as well as enhancing the student motivation in PBL group work while developing a positive interdependence approach. To avoid some of the problems associated with student empowerment of this type, schemes require openness in dialogue with students, planning, and close monitoring in the early stages.

The study has provided an insight and understanding of the interactive relationship between student variables, team contract, feedback context, their perceptions of peer assessment tasks, and the students' resultant participation approaches to PBL. By providing students with the autonomy to self-reflect and set their own goals, they developed a greater understanding and empowerment of their learning. By allowing the students to engage in the feedback process, it provided a vehicle for them to identify gaps in their understanding while linking the importance of GA's to the PBL experience.

CHAPTER 8 Discussion and Conclusion

This chapter provides an overall summary of the thesis and brings together the findings of the individual chapters. It also concludes the findings and outcomes and discusses the implications of the findings, the limitations and the recommendations for further research.

8.1 Introduction

Self- and peer-assessment and PBL have become popular in higher education. As life outside the classroom usually requires working with others, peer assessment is not only a viable option to measure student learning, but also to formally evaluate and document the attainment of related graduate attributes. Moreover, PBL has shown to be a valuable learning method for students to take ownership of their own learning, and professional and personal development, as well as a means of developing desired graduate attributes.

Recently, more and more emphasis has been placed on the adoption of PBL in engineering education and the issues of student engagement in assessment, and the validity and reliability of assessment. Savin-Baden (2004) claims that assessment is one of the most controversial concerns in PBL. Self- and peer-assessment has been commonly used in PBL as an assessment method. When students are involved with the various steps in the assessment cycle, significant increases in engagement, ownership and learning have been observed.

Consequently, research on student interpersonal effects on the outcome of assessment has been increasing. However, previous research on self and peer assessment have focused largely on the rater effects of self and peer grading, peer marking, and peer feedback between learner and teacher (Boud & Feletti, 1998). Research on the interpersonal process and its impact on the reliability and validity of peer assessment has been scarce (van Gennip 2001).

To show how well a graduate can demonstrate a graduate attribute is crucial from a quality assurance perspective of an undergraduate engineering programme. Much work has been undertaken in specifying graduate attributes and assessing knowledge or discipline outcomes (Barrie, 2004; Campbell, 2010; Hager, 2006; Symes et al., 2011b) but measuring the attainment of graduate outcomes, particularly generic outcomes, is contentious and difficult (Oliver, 2011). The challenge is to find transparent ways of affirming graduate achievements while at the same time ensuring the graduates themselves are assured of their capabilities. The measurement of these generic outcomes can be difficult, time-consuming or at times impossible particularly for academic staff who may feel ill-equipped for these tasks (Green,2009; Radloff et al., 2009).

In the proceeding chapters, this study presented cumulative arguments regarding the development, through PBL, attainment, and assessment of graduate attributes. In this Chapter, the main findings specific to each chapter will be summarised, followed by a discussion of the impact of the outcomes of this dissertation, limitations of the body of work presented here, and opportunities for further research.

This dissertation outlines the process of developing a PBL environment that allows students to develop GA's, as well as highlighting issues with the use of self-and peer assessment to reliably assess the attainment of those attributes.

8.2 An overview of the study

This research study was intended to answer a series of four questions focused on variables that may influence the reliability of self- and peer assessment in PBL that address engineering graduate attributes. The first research question was concerned with the extent that student variables; (a) Psychological Safety, (b) Interdependence, (c) Trust, and (d) Value Diversity have on the outcomes of peer assessment. The second research question examined strategies that might be put in place to mitigate the influences of student variables. This followed on to the following two sub-research questions: address the peer assessment process as a means of assessing graduate attributes, and 2) investigate whether peer assessment is a reliable method in assessing the attainment of GA's for engineering undergraduate students.

The main empirical findings are chapter specific and were summarised within the respective empirical chapters:

Chapter 2 sets out the institutions approach to developing, structuring and measures of proficiency of GA's in close consultation with industry. The findings show that industry expects a high level of proficiency across a broad range of attributes while stating current graduates fall far short of their expectations. The findings supported the adoption of a pedagogy that enables a high level of engagement and achievement of GA's.

Chapter 3 reported on embedding GA's within a PBL approach. The study examines the adoption of four problem based holistic practical projects incorporating peer and criterion referenced assessment. The study demonstrated how this holistic, integrated approach to PBL and assessment provide relevance of GA's for the students.

Chapter 4 reports on a study that allowed the mapping of the GA's through a PBL case study. The latter reported how each stage of the project and its related assessment linked to the relevant GA's and student learning.

Chapter 5 is a literature review aimed at presenting an overview of studies evidencing the effect of peer assessment on the attainment of GA's. The chapter raised the question of reliability and validity of peer assessment within the PBL context, by endeavouring to answer two research questions:

- Is peer assessment a reliable assessment technique in assessing graduate attributes within engineering PBL?
- Does peer assessment provide valid evidence abouts students attainment of graduate attributes?

This chapter provided evidence that peer assessment can be a reliable assessment technique and provide valid evidence in assessing GA's. The process, however, must be implemented in a way that allows students to acknowledge gaps in their learning and are equipped to put techniques in place to address the influence of student variables while value adding to the assessment process.

Chapter 6 is an empirical study focused on the impact of student variables on the peer assessment process, which examines the sub-research question, "To what extent are the outcomes of peer assessment of graduate attributes related to student variables?" The review of the relevant literature already evidence that student variables influence PBL group learning outcomes (e.g. Edmonson, 1999; van Gennip, Segers, & Tilleman, 2010). Based on the findings of this study, questions still remain unanswered as to the impact that student variables have on the outcomes of assessing GA's through peer assessment.

Chapter 7 sets out to investigate the second sub research question, "What strategies might mitigate adverse influences of student variables on the outcomes of peer assessment of maritime engineering graduate attributes in a team based PBL?" This chapter introduces the concept of a PBL formative model that

This study found that by introducing an additional reflective, mentor supported feedback approach to both the PBL and peer assessment process, students gained greater insight into the impact of student variables on the outcome of peer assessment.

The following section will synthesize the empirical findings to answer the study's research questions.

8.3 Summary of the findings

The purpose of this research was to explore the development of graduate attributes in the Bachelor of Engineering Maritime programme, the development by the learner of these attributes through PBL, and the use of self- and peer assessment as a reliable means of assessment of these attributes. In particular, this study investigated the influence student variables within a team environment has on the reliability of self- and peer assessment in the assessment of GAs.

The study focused on the different learning and assessment values of students that emerged from the analysis of the student variables characteristics that influenced the students approach to peer assessment within PBL teams. These were identified as psychological safety, trust, value diversity, and interdependence. Analysis carried out within this study showed that student variables have an effect on the reliability of peer assessment in assessing GAs within team based PBL.

Students in teams that were exposed to reflective and formative feedback adopted a positive interdependence approach to team development and the project, built trust and excellent communication skills, agreed and were more flexible in team role allocation, and demonstrated a high level of participation during supervised and unsupervised team meetings. They valued teamwork and had mutual respect for one another (i.e. value diversity). This was further evidenced in the approach they took to peer assessment, where there was a high correlation between tutor observed attainment of graduate attributes of each team member and overall team outcomes, and demonstrating a high level of psychological safety in assessing their peers. The latter attributed to a more reliable outcome of peer assessment.

Students in teams that were not provided with any formative feedback, but significant training in peer assessment and the outcomes of PBL adopted a negative interdependence approach to team development and the project and tended to focus on developing a more individual response to the project. Students engaged in team meetings, albeit tending to adhere exclusively to their individual roles within the team, and made some effort to abide to the team contract. Although there was evidence of trust, the students did not share the work equitably. Students demonstrated an understanding of team members differences (value diversity), but their negative interdependence approach encouraged passivity in individual team members approached to peer assessment. Although this approach did not appear to influence the project solution, the reliability of peer assessment results in these teams could be questioned.

Students who were not provided significant training or formative feedback adopted a non-interdependance approach to PBL and peer assessment, tending to approach the project with minimal contribution. Most students attended supervised team meetings, however, there was little evidence of good communication or mutual respect and trust. Team members tended not to refer to their team contract and completed work individually. This lack of trust and psychological safety was reflected in how they approached peer assessment. These students did not make a connection with the attainment of GAs through PBL and used peer assessment more as a tool to 'get back' at individual team members.

The evidence of the influence of student variables on the approach to peer assessment presented in Chapter 6 and the way they approached peer assessment presented in Chapter 7 indicates that students exposed to the PBL-formative model 2 setting were inclined to approach peer assessment with the assessment of graduate attributes as the primary focus. Greater engagement and determined value in the team contract and the concepts of peer assessment in the assessment of GAs are predictors of trust in the individual and their team members. The students developed a stronger resolve in trust for their team members, which mediates the relation between value diversity and psychological safety.

8.4 Conclusion

This research provides new insight into the impact of student variables on the reliability of peer assessment. An important finding in this study is that the Formative PBL-Assessment model 2 has identified key elements that influence how students approach and participate in problem-based learning and peer assessment of graduate attributes. The adoption of the a Formative PBL-Assessment model 2 has shown to develop a positive interdependence approach by students when in a problem-based learning environment. This approach has shown to allow students to develop a deeper approach to interaction in and understanding of their learning, attainment of graduate attributes and the outcome of peer assessment. The long term objective of the work will be the development of a SVTI model that would monitor and report on the impact of student variables on problem-based learning and peer assessment.

By helping students understand the impact of student variables on peer assessment, learn how to be part of a team, how to respect diversity within the team, build trust, how to take team roles and responsibilities and to feel safe in the problem based learning environment the greater the reliability and validity peer assessment has in assessing graduate attributes.

8.5 Implications and future research

This dissertation contributes to the body of knowledge of engineering education research, and scholarship of teaching and learning within the PBL environment. However, the use of the model is seen as a starting point for further research into the social nature of peer assessment.

For engineering educators considering the implementation of PBL into their teaching practice, this study offers not only insights into the impact of student variables on the reliability of peer assessment, but also strategies and a model that can be implemented to mitigate adverse aspects.

Additionally, this dissertation revealed the complexities of the interaction between student, academic and the pedagogy behind PBL, and the need to anticipate and support the transformation of both the learner and the academic when engaged in the PBL environment used to develop GAs. The results of this study will provide researchers and academics with perspective and insight into the implementation of the Formative PBL-Assessment model 2 to assess the attainment of GAs.

This research focused on the development using PBL and assessment through self-and peer assessment of GAs within a Formative PBL-Assessment 2 system and the influence of a series of student variables on the above. Future studies using a larger student cohort over multiple disciplines while delving deeper into these variables would yield critical information to better understand the influence of student variables on student performance, participation and engagement in self-and peer assessment using the model introduced in this study. The more insight and information that can be gained through research into the impact of student variables influencing self-and peer assessment, students and academics can become more knowledgeable with regard to the proper implementation, advantages and limitations of the Formative PBL-Assessment model 2.

8.5.1 Further Work

Further research would include the development of a student variables type indicator tool (SVTI) to evaluate natural interpersonal preferences of students in a PBL environment. The tool would build a student identity matrix that can be used to match team members and develop individual intervention strategies for students based on their SVTI. This includes prior training, making students confident with the objectives of peer assessment in assessing GAs, team organisation procedures, and the development of criteria on giving and receiving feedback against GAs.

As this study was not longitudinal but a snapshot of student experience in their final year-long design project. There was no scope for studying what knowledge and skills students developed through the implantation of the Formative PBL-Assessment model 2 and how they transferred that knowledge and skills into practice in other PBL environment and their use of peer assessment.

The main findings of this study about the enabling and inhibiting factors of student variables and their impact on the reliability of peer assessment and the success of problem-based learning provide the impetus for further research.

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Appendix 1 AMC – NCMEH Bachelor of Engineering Graduate Attributes

A. Demonstrate technical knowledge

1. Basic physics, chemistry and maths
2. Fundamental engineering science
3. Maritime technology, structures and/or systems (All)
4. Theoretical and experimental hydrodynamics and structural integrity of marine vehicles (NA)
5. Integration of maritime mechanical, electrical and systems engineering (MOS)
6. Fluid-structure interaction and integrity of offshore and subsea installations (OE)

B. Design for the maritime environment

1. Interpret design specifications and requirements
2. Conduct systems analysis of design problem
3. Identify design drivers and constraints
4. Innovate and develop new designs
5. Develop appropriate evaluation criteria
6. Assess designs against criteria

C. Solve maritime engineering problems

1. Identify and formulate problems
2. Conceptualise a range of solutions taking account of constraints
3. Optimise and critically review solutions
4. Converge on an accurate and realistic solution
5. Propose new directions/ideas based on findings
6. Think and consult beyond the engineering (technical) aspects of solutions
7. Deal with uncertainty in problem-solving

D. Manage, create, use and disseminate information

1. Locate and use relevant, good quality information
2. Make rational decisions when faced with information deficit or overload
3. Integrate ideas and information from outside the field of maritime engineering
4. Produce clear engineering diagrams and sketches
5. Create and maintain project/research files

6. Create and maintain evidence of professional experience
7. Practice basic document identification and control procedures

E. Communicate effectively

1. Write in a form appropriate to the audience (*e.g.* technical/non-technical, multicultural, multilingual)
2. Speak in a form appropriate to the audience
3. Use logical structure in written communication
4. Use logical structure in oral communication
5. Express technical ideas numerically and graphically.
6. Present own ideas, skills and knowledge to prospective employers, clients and stakeholders
7. Listen effectively to co-workers, employees, stakeholders and employee.
8. Discuss and debate ideas with industry and stakeholders

F. Work in teams

1. Define own role and participate in team projects
2. Manage own time and meet obligations in contributing to team projects
3. Contribute to group discussion and decision-making
4. Receive and respond to critical feedback
5. Constructively evaluate and comment on others' contributions and suggestion
6. Appreciate the value of diverse knowledge, ideas, beliefs and cultures in a team
7. Recognise and resolve conflict.

G. Manage self and others

1. Recognise gaps in own knowledge
2. Plan independent learning to fill knowledge gaps
3. Recognise, and learn from, mistakes
4. Manage self under pressure and operate within constraints (*e.g.* time, budget, resources, skills)
5. Value diversity by using effective interpersonal and intercultural skills
6. Motivate and mentor others, and accept mentoring from others
7. Plan and supervise the work of others
8. Demonstrate initiative and leadership while respecting others' roles

H. Negotiate the business environment

1. Develop maritime industry links, networks and awareness
2. Develop maritime industry experience in dealings with clients, industry stakeholders and employers.

3. Account for commercial, financial & marketing aspects of engineering projects
4. Manage projects within constraints of the maritime environment (*e.g.* time, budget, resources, skills)
5. Be aware of structure and roles of the industry workforce
6. Comply with legislation, codes, standards relevant to engineering in the maritime environment

I. Behave as a professional

1. Present a professional image (*e.g.* manner, timeliness, follow–through, dress, courtesy)
2. Distinguish the responsibilities and rights of professional engineering status
3. Explain ethical responsibilities, to society, colleagues, employer, environment and others, referring to an appropriate Code of Ethics
4. Practice engineering in an environmentally, socially and economically responsible way
5. Consult stakeholders
6. Undertake risk assessment and prepare to manage risks identified

J. Consider wider context of engineering knowledge and work

1. Link engineering knowledge with knowledge from other disciplines
2. Be aware of main environmental, social and economic issues associated with maritime engineering
3. Be aware of main local, national and global issues associated with maritime engineering

Appendix 2 Questionnaire

Student Variables and their effects on Peer assessment and Student learning

Have you been involved in a multicultural team?						
How many team projects have you been involved in?						
What was your main team role in each team?						
		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
		1	2	3	4	5
1	Members' roles were established prior to undertaking the project.					
2	Members' rarely expressed disagreement with other team members' goals.					
3	I often feel undervalued when contributing to group work.					
4	The roles and tasks allocated to individual members' are determined by their abilities, and not by external influences or first impressions.					
5	Establishing a good working relationship with other cultures is difficult.					
6	I feel uncomfortable working with people from other cultures.					
7	I think my cultural background provides me with a better work ethic than other cultures.					
8	Culturally diverse teams have an impact on my learning.					
9	I respect the views of people of different socio-cultural backgrounds.					
10	The team appears to break up into different socio-cultural sub-groups.					
11	Conflict between different sub-groups within the team is a problem.					

12	I don't appreciate feedback from members of a different sociocultural background than mine, as they don't understand me.					
13	I feel my learning is impaired when involved in socio-culturally diverse teams					
Gender:		Age:	Nationality:			
Ethnicity:		Place of Birth:	Native language:			

Appendix 3 Team Contract Template

TEAM CONTRACT TEMPLATE

Team Name: Click here to enter your team Name. Date: Click here to enter Date

Team Members:

1. Click here to enter member's name.
2. Click here to enter member's name.
3. Click here to enter member's name.
4. Click here to enter member's name.
5. Click here to enter member's name.
6. Click here to enter member's name.

Please sign below against each team member number

1. **–**
2. **–**
3. **–**
4. **–**
5. **–**
6.

Team Relationships

As a team define consensus expectations about productive with-in team relationships. What constitutes the relationships needed for productive, enjoyable teamwork? How are these relationships developed and maintained? In the spaced provided below, please address these issues for your team.

1. **Inclusive climate.** Describe what is required for all members of a team to feel safe and valued, and explain member's commitments to achieve this inclusive environment.

Click here to enter text.

2. **Member Commitment.** Identify ways the team will systematically strengthen member commitments to the team and establish a clear team identity for all members.

Click here to enter text.

3. **Conflict Resolution.** Define the strategy your team will use to resolve conflicts that arise and leverage these challenges into opportunities for growing team performance.

Click here to enter text.

Joint Achievements

As a team, define consensus expectations about team goals and joint achievements. How will goals be used to drive overall team performance? In the spaced provided below, please address these issues for your team.

1. **Goal Establishment.** Define the team and project goal(s) to which all team members are committed. "our team is committed to…."

Click here to enter text.

2. **Planning and Management.** Describe how your team will establish plans, execute plans, and review progress with regards to achieving team goals. How will these processes be managed, and by whom?

Click here to enter text.

3. **Joint Work Products.** Describe how your team will conduct meetings and joint work so that synergies yield high-quality work products (decisions, ideas, reports, etc.) that benefit from unique contributions of all members.

Click here to enter text.

Member Contributions

As a team, define your consensus expectations about individual team member contributions. How will work be allocated, performance standards established, and performance reviewed to ensure member productivity? In the spaced provided below, please address these issues for your team.

1. **Work Allocation.** Define how work will be allocated to individual members of the team. Address issues of leadership, back up, and fairness.

Click here to enter text.

2. **Performance quality.** Describe your team's plan for achieving high performance from each team member. Address work standards and accountability that will ensure success. Who is responsible to whom, and on what timeline?

Click here to enter text.

3. **Member Growth.** Describe your team's plan for growing team member capabilities and responsibilities over the duration of your project. How will you prepare members for growth and leadership in a complex, changing project?

Click here to enter text.

Team Information

As a team, define consensus expectations about handling project information. How will communication within and outside the team are managed? How will ideas and decisions be documented? In the spaced provided below, please address these issues for your team.

1. **Internal Communication.** Define notifications, records of meetings, exchange of information, and other in-team communications be conducted to empower all members for success. What communication protocols should be followed including timeliness for each member?

Click here to enter text.

2. **Stakeholder Communication.** Define communication expectations for each team interactions with key outside stakeholders. With whom will you communicate regularly? Who is responsible? How will appropriate confidentiality be maintained?

Click here to enter text.

3. **Knowledge Assets.** Define how project information assets are, developed, managed, and safeguarded. What project records will be maintained and by whom? How will personal engineering notebooks and team records are developed to produce the greatest value? How will documentation be managed?

Click here to enter text.

4. **Decision making Policy.** Define how decisions will be made within the team (by consensus? by majority vote?).

Click here to enter text.

5. Method of **record keeping** (Who will be responsible for recording & disseminating minutes? How & when will the minutes be disseminated? Where will all agendas & minutes be kept?).

Click here to enter text.

Roles and Responsibilities.

Complex projects require shared leadership – different individuals leading different portions of the project. As a team, either based on each individual Belbin results or as identified for each member the leadership or backup responsibilities for which this person is accountable to the team.

Member Name: Click here to enter text.

Job Title or role	Principle responsibly

Member Name: Click here to enter text.

Job Title or role	Principle responsibly

Member Name: Click here to enter text.

Job Title or role	Principle responsibly

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1. Please provide the rationale behind each team member's allocated role and responsibilities.

Click here to enter text.